

## Something **NEW** Under the Sun

Take a tour of the newest research in pavements and materials presented at the 88th meeting of the Transportation Research Board.

**D**igital stereo imaging of pavement conditions ... warm-mix asphalt and reclaimed asphalt pavement ... ground-penetrating radar and bridge decks ... temporary rumble strips in work zones. These just a few of the many topics of peer-reviewed research in surface transportation presented at the 88th annual meeting of the Transportation Research Board in Washington, D.C.

More than 10,000 researchers, engineers, technicians and stakeholders attended the meeting this year. Following are summaries of some of the papers of interest. (For more information about TRB, visit <http://trb.org>.)

**Pavement texture and condition analysis** via three-dimensional images obtained through stereo digital photos offers an alternative to classic mobile imaging, Edgar David de León Izeppi, Virginia Tech Transportation Institute, Gerardo W. Flintsch, Virginia Tech Transportation Institute, Mohamed I. Saleh, Virginia Polytechnic Institute and State University, and Kevin K. McGhee, Virginia Transportation Research Council, say in their paper, "Area-Based Macrotexture Measurements: A Stereo Vision Approach."

Textural character is a common indicator and influence of pavement condition and thus future performance, the authors said, as they introduced a new system to measure the

texture of a pavement surface using a stereo vision camera. Their system uses relatively low-cost, off-the-shelf components for capturing images of pavements to obtain three-dimensional surface maps of pavement. They compared their prototype to more conventional texture-measuring systems.

The stereo vision technology they describe maps a true 3-D surface map to continuously determine textural properties of road surfaces at highway speeds. "The development of a relatively low-cost pavement surface texture measurement system that can conduct wide-area measurements instead of thin longitudinal lines can provide an accurate characterization of pavement surfaces," the authors say. "This is needed to better determine most tire-pavement interactions, such as friction, noise, splash and spray, rolling resistance, and tire wear."

"The results indicate that the stereo-vision-based technology can provide a

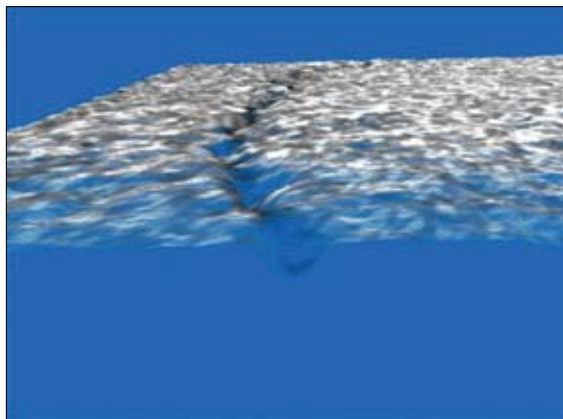
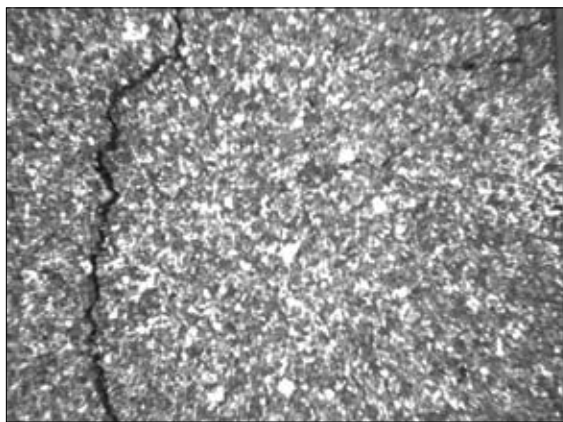
more accurate (and relevant) methodology for evaluating pavement surface texture than most currently available technologies," the authors say, calling for the larger scientific community to develop methods for characterizing texture that apply 3-D surface mapping to further understand and describe the tire-pavement interface.

"Adequate, effective, and rapid assessment of pavement texture can be used to support wet-accident reduction programs, help reduce splash and spray conditions, reduce tire-pavement noise, and monitor the quality of the finished traveled surfaces," de León Izeppi, Flintsch, Saleh and McGhee note. "However, current approaches to measuring texture features in road pavements have several limitations. Traditionally, sand-patch measurements (ASTM E965) have been used to evaluate the texture of a road pavement. This and other static measurement devices (such as the Circular Track Meter, ASTM E2157) have



▲ Small-sized aggregate is applied to treat a bleeding chip seal

Photo courtesy of W. James Wilde and Eddie N. Johnson



▲  
◀ Conventional (top left) and digital stereo (bottom left) view of surface texture, including crack

*Photo courtesy of Edgar David de León Izeppi, Gerardo W. Flintsch, Mohamed I. Saleh and Kevin K. McGhee*

the disadvantages of interrupting traffic, requiring traffic control measures, and providing only a limited sample of the road texture. Although high-speed laser profilers can conduct continuous measurements of the pavement macrotexture, they only measure very thin longitudinal lines and may miss important features adjacent to these lines."

The main advantages of their concept include a more accurate — and relevant — methodology for evaluating pavement surface texture than conventional laser-based technologies; maximized return on road construction investments by providing a more objective tool to measure the texture of finished pavement layers, detecting non-uniform areas, and verifying the achievement of pre-established performance targets; the system can be mounted on a moving vehicle, allowing operation under routine traffic conditions, eliminating the need to shut down lanes with traffic control; and it can be used in conjunction with continuous friction measurement devices to obtain a

comprehensive assessment of pavement safety features.

#### **Smoothness-degrading bumps**

in thin-lift hot-mix asphalt overlays, or in the first of two asphalt lifts, often are the result of crack sealing techniques, but they can be overcome, said W. James Wilde, Minnesota State University, Mankato, and Eddie N. Johnson, Minnesota Department of Transportation, in their paper, "Effect of Crack Sealant Material and Reservoir Geometry on Surface Roughness of Bituminous Overlays."

Wilde and Johnson describe the effects of crack sealant material type and the geometry (shape) of the routed cracks in the existing surface on the formation of bumps in bituminous overlays. A matrix of four sealant-type treatments and six geometries was designed, and implemented in a test section in Jackson County, Minn., constructed in September 2007. "The results of this investigation indicate that cooler pavement surface temperatures, no

overband, hot-poured crumb rubber, and hot-poured elastic sealants provided the best resistance to the formation of bumps in overlays."

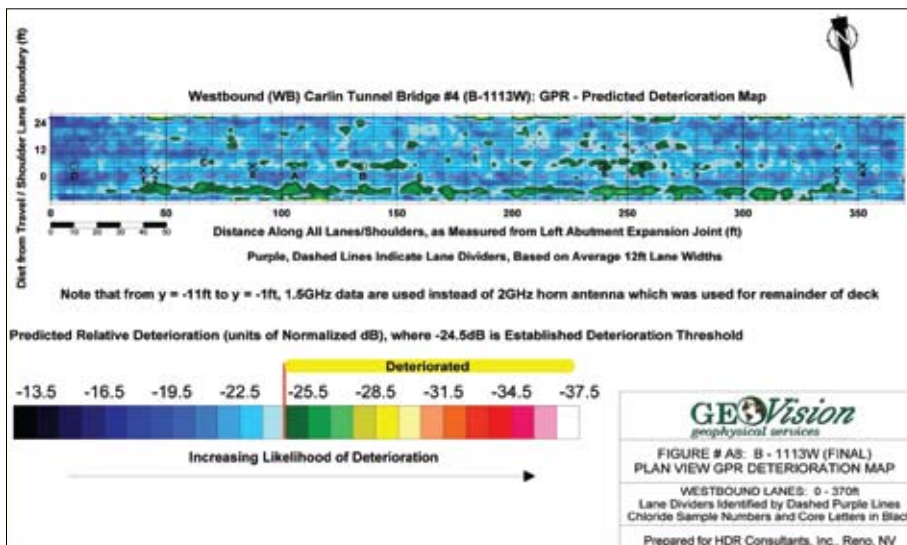
The field test was designed to evaluate the effects of crack sealant material and crack reservoir geometry on the formation of these bumps in the overlay. As an additional benefit, a significant air temperature difference existed on the two days during which the two lanes were overlaid, providing an additional variable in the test, as during overlay construction, the pavement temperature can affect the formation of bumps.

A one-mile segment of a highway was selected. The test section was divided into 20 segments approximately 250 feet long, each of which contained at least 10 transverse cracks. Sealant material types were none, crumb rubber, elastic and low modulus; and reservoir geometries were not routed, with normal overband (up to 3 inches); routed 3/4-by-3/4 inch with normal overband; routed 3/4-by-3/4 inch with no overband; routed 1-by-3/4 inch with sealant

recessed 1/4-inch below surface; and routed 1-1/2-by-1/2 inch with normal overband; and saw and seal 0.50-by-0.63 inch.

They all represented standard maintenance practices in Minnesota, as well as some less common combinations, the authors said. Each of the materials and geometries (with the exception of the "no sealant" option) were combined in the test site segments, for a total of 19 segments.

The authors concluded that with respect to sealant material, the low modulus sealant (Minnesota DOT Specification 3725) performed the least favorably, in both air temperature conditions. No sealant at all produced the best results, but only somewhat better than the other two Mn/DOT types (crumb rubber – 3719 and elastic – 3723). With respect to reservoir geometry, those with the largest width dimensions (1-by- 3/4-inch recessed and 1-1/2-by-1/2-inch normal) performed the least favorably in both air temperature conditions. "The best-performing geometries were 3/4-by-3/4 inch with no overbanding, and saw and seal, primarily those with narrow width and no overband," they say.



▲ Final bridge deck assessment via ground-penetrating radar was used to execute preventive repairs to deck to forestall major repairs.

Photo courtesy of Francisco A. Romero, Michael Premo, David Severns and John G. Diehl

**Bleeding and flushing** of chip seals are similar, but they need to be differentiated to determine their optimum treatments, say William D. Lawson and Sanjaya Senadheera, both of Texas Tech University in their paper, "Chip Seal Maintenance: Solutions for Bleeding and Flushed Pavement Surfaces."

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Factors that contribute to bleeding and flushed chip seals include issues with aggregate, binder, traffic, environment and construction, they write. "There is no better advice for dealing with bleeding and flushed chip seals than to avoid the problem from the outset by employing a preventive maintenance perspective," the authors say. "Bleeding is an immediate maintenance problem that must be addressed using corrective, or in some cases emergency, maintenance."

The basic approaches used to treat bleeding include bridging over the live asphalt by applying aggregate of various types and gradations, cooling off the pavement surface by applying water with or without additives, or removing the bleeding asphalt and rebuilding the pavement seal.

Flushing, in contrast to bleeding, is typically not a maintenance problem that must be addressed immediately, they say. The basic approaches to treat flushed chip seals are to retexture the existing surface or to add a new textured surface over the flushed pavement," Lawson and Senadheera say. "Three promising areas for further research and implementation relative to bleeding/flushing solutions include the use of lime water, the use of ultra-high-pressure water cutting, and the use of the racked-in seal at intersections."

The maintenance thresholds that call for treatment of a flushed pavement include a slippery pavement surface, low skid resistance, and rutting and water accumulation in the wheel paths, they say. The approaches maintenance forces employ to treat flushed asphalt pavements are to retexture the existing pavement surface, or to add a new textured surface over the flushed pavement. "Intersections can be especially problematic," Lawson and Senadheera write. "The approaches to treat bleeding and flushed pavements at intersections are to retexture the existing pavement surface, or to replace the chip seal with a new, more durable, pavement material."

**Ground-penetrating radar (GPR)** can be used for advanced diagnosis for overlay failures on bridge decks, write Francisco A. Romero, Underground Imaging Technologies, Inc., Michael Premo, HDR Engineering, Inc., David Severns, Nevada DOT, and John G. Diehl, GEOVision Geophysical Services, Inc. in their paper, "I-80 Corridor GPR Bridge Assessments: Deterioration Mapping of Asphalt- and Polymer Concrete-Overlaid, Reinforced Concrete Decks [in] Elko County, Nevada."

GPR surveys of asphalt-overlaid, reinforced concrete decks were performed on 14 bridge structures along I-80 in Elko County, Nev. "A thin polymer concrete (PC) overlay initially applied to the bare concrete was later overlaid with asphalt," the authors say. "GPR analysis quantified upper deck deterioration on maps used to identify advanced concrete degradation."

For this paper, 1.5GHz ground-coupled (GC) and 2GHz air-coupled (AC) data were collected throughout identical scan paths (control data) along travel and right shoulder lanes within lane closures at 5 mph, allowing traffic to flow

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in fast lanes. High-speed data acquisition employed 2GHz AC sensors at 20 mph without closures, assisted only an attenuator truck.

"Control data were used to characterize variations in signal amplitude and attenuation response between both sensor types so equivalent deterioration quantity predictions and contour maps could be produced," the authors say. "2GHz AC data (passing lanes) was merged with normalized

1.5GHz data (travel and shoulder lanes) collected closer to curbs or barrier walls. Preliminary maps helped target core and chloride sampling to augment GPR data, allowing more accurate condition assessment maps to be generated.

As a result of these tests, the Nevada Department of Transportation repaired one concrete deck and allocated resources elsewhere based on the final GPR deterioration quantity estimates, and considered the project a cost-saving

success. The 2GHz sensor clearly imaged the asphalt/PC overlay and its signal amplitude was measured and mapped. "Good correlation exists on several decks between PC/concrete interface response and deteriorated zones identified on the GPR maps," they say, adding that the process provides a way to develop an early diagnosis process for PC-overlay failure to help mitigate unnecessary deck deterioration.

**Warm-mix asphalt additives** tested in a study boost the workability of asphalt mixes containing reclaimed asphalt pavement (RAP), while altering binder attributes, write Alexander J. Austerman and Walaa S. Mogawer, both of the Pavement Research Institute of Southeastern Massachusetts (PRISM) of the University of Massachusetts-Dartmouth, and Ramon Bonaquist, Advanced Asphalt Technologies, LLC in their paper, "Evaluating the Effects of Warm-Mix Asphalt Technology Additive Dosages on the Workability and Durability of Asphalt Mixtures Containing Recycled Asphalt Pavement."

"The asphalt paving industry is facing two major challenges," the authors say. "These include increased demands for environmentally friendly paving mixtures, and [the] increasing costs of raw materials. To address these challenges, it has been suggested to incorporate WMA technology additives and more recycled asphalt pavement into new HMA mixtures."

The authors contemplate both challenges in the study, which investigated the influence of the dose of two WMA additives (Advera and Sasobit) on the composite binder properties, mixture workability and mixture durability. Two Superpave mixtures, a 12-millimeter with 10-percent recycled asphalt pavement, and a 19.0-millimeter with 25 percent recycled asphalt pavement, were used for this study.

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Successful temporary rumble strip configuration was close to work zone and used multiple sets of strips.

Photo courtesy of Deborah S. McAvoy, Peter T. Savolainen, Vivek Reddy and Satya V. Pinapaka, Joseph B. Santos and Tapan K. Datta

"Binder testing showed that the addition of Sasobit at a dose of 1.5 percent and 3.0 percent by weight of the binder changed the performance grade of the binder and decreased the binder viscosity," Austerman, Mogawer and Bonaquist say. "The addition of Advera at dosages of 0.1 percent and 0.3 percent by weight of mixture did not change the performance grade of the binder and only marginally changed the binder viscosity."

Workability testing on the mixtures showed that both WMA additives improved the workability of the mixtures containing RAP at any of dosages tested. Durability testing showed that all the WMA additives tested at any dose increased the moisture susceptibility of the mixture. "This indicated that for particular WMA additives anti-strip may be required in order to produce a durable mixture," the authors said. "Furthermore, durability testing may be an integral step when developing a mix design procedure for mixtures with WMA additives."

**Temporary rumble strips** work to slow drivers down as they approach work zones, but their application can be tweaked for optimum performance, Deborah S. McAvoy, Ohio University, Peter T. Savolainen, Wayne State University, Vivek Reddy and Satya V. Pinapaka, both of HNTB Corp., Joseph B. Santos, Florida DOT, and Tapan K. Datta, Wayne State University, write in their paper, "Evaluation of Temporary Removable Rumble Strips for Speed Reduction."

Removable rumble strips were installed at construction work zones along State Route 31 in Charlotte County, Fla., to help reduce travel speeds of vehicles entering work zones, and speed studies were conducted 5,500 feet and 600 feet upstream of the work zone to determine differences between work zones equipped with temporary rumble strips and those that were not.

"A comparative parallel study revealed that travel speeds were not significantly different 5,500 feet upstream of the work zone regardless of whether or not temporary rumble strips were present," the authors say. "The propor-



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tion of drivers exceeding the posted speed limit was also not identified as a problem in either case."

The strips worked much closer to the zone. "At 600-feet upstream of the work zone, the temporary rumble strips produced a substantial reduction of over 8 mph in comparison to those locations without rumble strips," McAvoy, Savolainen, Reddy, Pinapaka, Santos and Datta write. "This reduction was more pronounced than those experienced in several previous evaluations and temporary rumble strips appear to become more effective when they are placed closer to the work zone and when there are several sets of rumble strips placed in succession. The use of temporary rumble strips in advance of construction work zones appears to be a practical countermeasure to reduce vehicular speeds and to improve driver and worker safety."

The speed reductions experienced at these Florida study locations were relatively high in comparison to several previous evaluations of temporary rumble strips, they say. Consequently, they compared the results of this research to previously published studies to determine potential reasons for these discrepancies. Their review confirmed that, in general, temporary rumble strips appear to become more effective when they are placed closer to the work zone and when there are several sets of rumble strips placed in succession.

**Micromilling is indicated** over conventional milling for Georgia DOT overlays involving its new porous European

mix, wrote James Lai, Georgia Institute of Technology, and Mark Bruce, David Jared, Peter Wu, and Sheila Hines, all of the Georgia DOT in Georgia's "Evaluation of Surface Texture, Interface Characteristics, and Smoothness Profile of Micro-milled Surface."

"Friction courses in Georgia such as the open-graded friction course (OGFC), or the new porous European mix (PEM), rarely have been placed directly on top of a conventionally milled surface," the authors say. "Such placement could cause delamination of the surface layer, due to poor bonding between the friction course and the milled surface, and to the likelihood of surface water being trapped in the valleys of the rough milled surface. Thus, a new layer of dense-graded surface mix would have to be placed on the milled surface before a new friction course could be placed on top of it. Use of the micromilling technique could address this problem."

To investigate, Georgia DOT personnel studied micromilling in conjunction with the placement of 15.6 miles of PEM overlay on I-75 south of Macon. The Georgia DOT Special Provision for the micromilling and PEM overlay stipulated that the micromilling operation must produce a milled surface with a ridge-to-valley depth (RVD) in the surface texture of 1.6mm and would require corrective action when RVD exceeded 3.2mm.

The differences between conventional milling and micromilling of asphalt pavements lie primarily in the milling drums used and in the control of milling operations, although both

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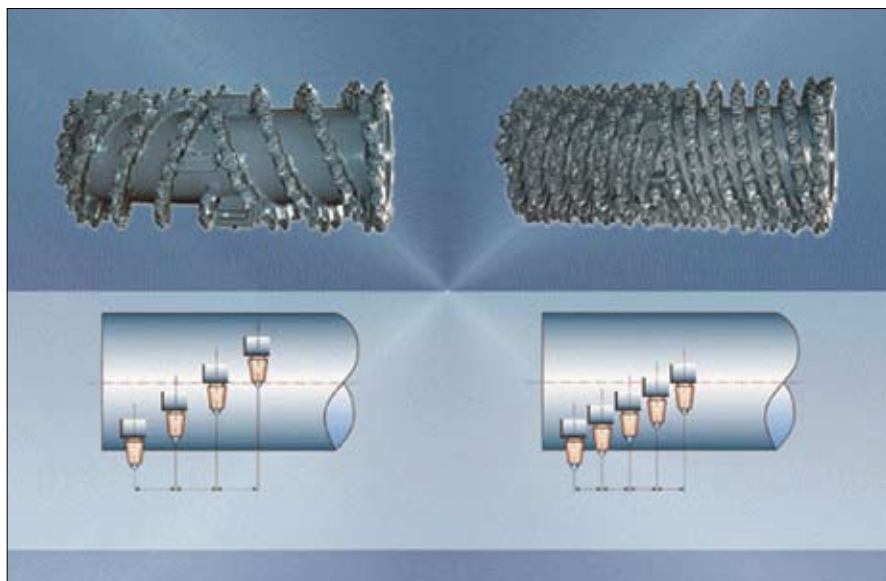
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operations could use the same milling machine. "There are more teeth at a closer spacing for a micromilling drum compared than with a conventional milling drum," Lai, Bruce, Jared, Wu, and Hines write. "A 12.5-ft.-wide micromilling drum has approximately 500 teeth, compared with about 180 teeth for a conventional milling drum of the same width. With the differences in the milling drum construction, together with better control of milling operations, micromilling is designed to produce a more uniform and smoother milled surface and finer milled surface texture than that of a conventional milled surface."

The micromilling and PEM overlay project investigated was located on I-75 near Perry, about 120 miles south of Atlanta. The project was 15.6 miles long with three lanes in both directions. The Circular Track Meter and the Ultra Light Inertia Profiler (ULIP) were used for measuring the macrotexture of the milled surface. Results from the eight test sections indicated that by keeping the milling speed to about 20 feet-per-minute or slower for the milling equipment used in this project, the milled surface texture depths could meet the 1.6-millimeter and 3.2-millimeter requirements.

Lastly, the bond strength testing was performed on the cores taken from the test sections with 0.06 gallon-per-square-yard and 0.08 gallon-per-square-yard tack rates. For the cores taken after seven weeks, the bond strengths were below 100 psi and were considered marginal against potential slippage failure. The bond strengths in both test sections increased substantially from seven weeks to seven months. The cores taken from the test section with 0.08 gallon-per-square-yard tack rate had higher bond strengths than that with 0.06 gallon-per-square-yard tack rate. No slippage failure was observed on all of the PEM surfaces of this project seven to nine months after construction. ❖



▲ Conventional (left) and fine texture drum (right) with 5/16-inch bit spacing.

*Photo courtesy of Wirtgen America, Inc.*