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The National Center for Asphalt Technology (NCAT) study on longitudinal joints has determined that Crafco Pavement Joint Adhesive is superior over all other joint sealant products and techniques tested to reduce longitudinal joint cracks and joint failure - Minnesota Transportation Board Research Report

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On the cover: Scrub seal application is demonstrated at National Pavement Preservation Conference 2012 in Nashville. Don’t miss field demos at NPPC 2016 this October; see article p. 11.

IMAGE CREDIT: Tom Kuennen
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For greater levels of profit and productivity, all signs point to Ingevity. Learn more at evotherm.com.
Why the Asphalt Institute Contributes to FP² Inc.

Pete Grass, president, Asphalt Institute, tells why his association directly supports FP² Inc. with its financial contributions:

Our core interest is all things binder ... how it performs in the field, how it’s modified, and how it’s used ... including asphalt emulsions. Emulsions are taking on more importance because they can create very high-performing products in pavement preservation, and that’s really important to our core membership.

As an industry we promote the fact that agencies can considerably extend the life of those pavements via pavement preservation. We need to educate the DOTs on the value and use of emulsion-based products, as well as thin asphalt overlays, and do it in a smart way. This effort is extremely important in terms of how FP² is growing the pavement preservation market for our members, our members’ customers, and for the liquid asphalt suppliers that serve the market.

Our support of FP² helps agencies understand the alternatives they have for preserving pavements at the right moment in their distress cycles, and that it’s far more economical – and will spread budget dollars a lot farther – to treat a pavement at the right moment. FP² is the vehicle for that education.

And that’s why we support FP², and will continue to do so. But we all need to push harder, because there’s a lot more work to be done. We want to see the companies that have a vested interest to step up to the plate and directly support FP² – not only financially, but also with talent and energy – to promote the ideals of FP² and to achieve its mission. We urge them to consider a direct contribution to FP² to help grow their own businesses in promoting pavement preservation to their customers.

Please consider joining leading industry businesses and national associations in supporting FP². For more information, contact executive director Jim Moulthrop, P.E. (PA, AZ) at 512.970.8865 or jimmoulthrop@gmail.com.
As I write this, spring is in the air and we are all looking forward to a successful 2016 pavement preservation season. Budgets are passed, bids and contracts are in place, and we are ready with the equipment and crews. Our focus turns to the immediate events of completing projects and not necessarily to long-term issues.

While you pursue your projects, FP2 Inc. is working for you in many ways. Our efforts are focused on long-term issues, and how we as an industry can expand the use of pavement preservation via advocacy, research and communication.

Most recently we have been focused on passage of a long-term surface transportation reauthorization that is properly funded, and clarifies pavement preservation’s eligibility for funding in major programs such as the Surface Transportation Program and the National Highway Performance program.

We finally achieved this success with the passage of the new FAST Act, which has a five-year term. This is important to both agencies and industry, as it lets them plan for the future and develop long-term programs and commitments. But while this legislation funds the FAST Act with some creative short-term, one-time funding measures, it does not address the long-term funding of our transportation network. Going forward our legacy Highway Trust Fund will not fund our transportation needs without major changes.

The real question for the future is how we will fund transportation at all levels, national, state and local. Since the 1990s, transportation funding has remained at nearly constant dollars while social programs and other expenditures have spiraled upward. Certainly the percentage of government dollars spent on transportation at all levels versus the total budgets is much lower than in the past.

In 2015, federal spending was $3.8 trillion while the federal transportation spending was roughly $50 billion, or less than two percent of the budget. The question is why is it so low comparatively, and what do we do going forward? What happens in five years when the FAST Act funding runs out?

We all recognize there are issues with the Highway Trust Fund. We need more funding; however, the gas tax has been stuck at 18.4 cents since 1993. In the meantime the CPI is up over 300 percent. Cars are more efficient and use less fuel, which means less gas tax coming in. We have more electric and natural gas vehicles that pay nearly nothing to use the roads. In addition, we have greater funding demands for accessibility at intersections, for recreational bike paths, and for environmental perks such as landscaping and sound barriers. They all increase demands on limited highway funds.

So how do we fund transportation at the federal level in five years? It appears without some additional user fees the Highway Trust Fund will not come close to funding our needs. What is the proper user fee? Will it be an increased fuel tax? Mileage-based or weight-based taxes? Vehicle-based fees?

The point is, we must all continue to deliver our message for the need for increased transportation funding to Congress, state legislators and local governments. The FP2 board has committed to continue our advocacy efforts in Washington. We have no choice, as those five years will go by quickly, and we need to be part of the solution if we are to have a seat at the table. We invite your opinions or suggestions for solutions; please send to FP2 executive director Jim Moulthrop, our Washington D.C. counsel Tracy Taylor, or me. I would also encourage you to get involved and communicate with your legislators.

I commend some of our association supporters which are developing and implementing marketing programs for their products and processes. These efforts—along with the ongoing pavement preservation research we are funding at NCAT and MnROAD—are key to getting the message out about pavement preservation, not only to the agencies, but also to the political decision makers. We all need to cooperatively sell the need for both our products, and more long-term funding.

Lastly, I want to finish by mentioning Dr. Mary Robbins, who has left NCAT and returned to Ohio. She’s been an integral part of pavement preservation research, along with Buzz Powell, at NCAT, and was instrumental in the development of the NCAT/MnROAD partnership. It’s been a great pleasure to work with her, and I wish her the best of luck in her new endeavor.
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ABOUT FP² INC.

FP² Inc. is a non-profit trade association organized under the Internal Revenue Code Section 501(c)(6), and is supported by the pavement preservation industry, contractors, material suppliers and equipment manufacturers.

Formerly known as the Foundation for Pavement Preservation, FP² supports the adoption of pavement preservation at all levels of government, and works to ensure that pavement preservation becomes a part of road programs from coast-to-coast. It also supports valuable research in pavement preservation, and works in close cooperation with the Federal Highway Administration (FHWA), the National Center for Pavement Preservation (NCPP), and regional pavement preservation partnerships and state-based pavement preservation centers.

FP² also sponsors key promotional activity events, such as international and national pavement preservation conferences. It supports distribution of promotional information to support pavement preservation, such as brochures and the quarterly magazine Pavement Preservation Journal.

Please consider joining the leading-edge businesses and national associations above in making a financial commitment to the future of pavement preservation by supporting FP². For more information, contact executive director Jim Moulthrop, P.E. (PA, AZ), (512) 979-8865, jimmoulthrop@gmail.com.

*Displayed organizations and businesses are limited to those contributing in the last six months of 2015
National Pavement Preservation Conference

how fp2 works for you

best practices sustainability asset management partnerships accreditation quality management certifications materials equipment technologies research field demonstrations

OCTOBER 11-14
NASHVILLE, TN

National Pavement Preservation Conference

OCTOBER 11-14
NASHVILLE, TN

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pavement preservation journal 11
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Opportunities to observe placement demonstrations for several types of pavement preservation treatments.

Individual perspectives from leaders of industry, government, and academia about the need to protect our roadway investment through preservation.

A forum for Regional Pavement Preservation Partnerships underwritten through the AASHTO Transportation System Preservation—Technical Services Program (TSP-2).

A national networking opportunity to share technology, experiences, and issues affecting agencies and industry alike.

EXHIBITS

Adds to the educational experience! An important part of this conference is the participation of exhibitors who offer pertinent products and services. Attendees can obtain the latest information about hundreds of products and services available for pavement preservation programs and applications.

Exhibitors should register for space at the conference online at www.nationalpavement2016.org or by submitting the enclosed form with payment.

SPONSORSHIPS

This conference will not only celebrate the technical achievements in the preservation field, but also those who believe in and articulate the vision. We salute the organizations that provide significant support and contributions to better the state of the practice. Your sponsorship will help ensure a successful meeting!

Please see enclosed registration form for opportunities available to those who share the vision.

PAVEMENT PRESERVATION PARTNERSHIPS

The pavement preservation partnerships are regional forums of pavement professionals and practitioners—from state agencies, contractors, suppliers, consultants, academia, and local and federal government officials—all working together to take advantage of the synergy to be gained from sharing information and identifying common issues for further investigation.

The Partnerships—Midwest, Northeast, Southeast, and Rocky Mountain West—each share and publicize information describing improvements in research, design, specifications, materials and construction practices, and promote the benefits of pavement preservation through education and outreach.

LOCATION

The conference will be held at the Renaissance Nashville Hotel, 611 Commerce St., Nashville, TN 37203.

NON-INVITATIONAL TRAVELERS. Please contact the hotel at (506) 474-2009 or (888) 236-2427 and ask for the “National Pavement Preservation” block. The cut-off date for the reduced rate of $191/night is September 16, 2016.

STATE & PROVINCIAL TRAVELERS. TSP-2 invitees do not call the hotel for a reservation, but complete and return the Travel Planning Request Form found online at www.nationalpavement2016.org/register. Please follow the instructions on the form.

SPOUSE/GUEST REGISTRATION

Spouses and guests attending the conference can explore Nashville and see the local attractions. There will be no formal program.

Spouse/Guest registration includes breakfast and lunch on Tuesday, Wednesday and Thursday, and the Tuesday evening conference reception. The cost is $250 per person.

TRACK 1. PAVEMENT PRESERVATION BEST PRACTICES & TECHNOLOGY

- Preservation Basics for High- and Low-Volume Roads
- Safety Initiatives
- Quality Management
- Advancing New Product Technology
- Pavement Preservation Best Practices

TRACK 2. SUSTAINABILITY

- Recycling & Reuse
- Environmental Impacts
- Economics of Preservation
- Societal Benefits and Implications
- Sustainability Case Studies

TRACK 3. RESEARCH, TRAINING & CERTIFICATION

- Special Projects and Studies
- NCAT/MnROAD Studies
- LTAP Efforts to Advance Pavement Preservation
- Certification and Accreditation
- Emerging Technologies

TRACK 4. PAVEMENT & ASSET MANAGEMENT

- Agency Implementation of the FHWA Asset Management and Pavement Performance Requirements
- Condition Data Needed for Pavement Preservation
- New Technologies for Pavement Measurement
- Decision-making Influences and Actions
- Pavement Management: Putting the Data to Work

PLACEMENT DEMONSTRATIONS

On Wednesday afternoon you will be treated to an array of demonstrations showcasing various pavement preservation techniques used across the country. This is a unique opportunity to see many different pavement preservation applications placed side-by-side in a traffic-free, secure location just a short distance from the hotel.

Buses are available to transport attendees between the conference hotel and the demonstration site.

Demonstrations will include:

- Fog Seals
- Surface Retexturing
- Crack Treatments
- Concrete Pavement Technologies
- Scrub Seal
- Micro Surfacing
- Thin HMA Overlay

The demonstrations afford an opportunity to gain knowledge about many treatments in the preservation toolbox and have your questions answered by experts.

MORE INFORMATION http://www.nationalpavement2016.org/
ALL STATES MATERIALS GROUP LEADS THE INDUSTRY WITH INNOVATIONS IN PAVEMENT PRESERVATION TECHNOLOGY.

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AHEAD OF THE CURVE
## Conference Agenda

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<td>Regional Partnership Meetings (Midwestern, Northeast, Rocky Mountain West, Southeast)</td>
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<td>Four concurrent presentation sessions</td>
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<td>Field Demonstration Briefing</td>
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<td>11:30 AM – 12:45 PM</td>
<td>Field lunch at demonstration site</td>
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<td>Field Demonstration</td>
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<td>Load buses and return to hotel</td>
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<td>On your own</td>
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<td>Regional Partnership Meetings (all invited)</td>
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<td>Industry Roundtable</td>
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<td>11:30 AM – 12:00 PM</td>
<td>Lessons learned and conference wrap-up</td>
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At press time in April the growing slate of speakers – both firm and invited – for the No. 1 pavement preservation event of 2016, the 2nd National Pavement Preservation Conference, will give a delegates an idea of the value they will receive when they journey to Nashville.

The theme of NPPC 2016 is Continuing the Drive for Change, and the conference will be held at the Renaissance Nashville Hotel in downtown Nashville from Tuesday, Oct. 11, to noon Friday, Oct. 14, 2016.

TUESDAY, OCT. 11
Tuesday morning will feature meetings of the Midwestern, Northeast, Rocky Mountain West and Southeast Pavement Preservation Partnerships. Exhibitor displays also will be available for visits.

Tuesday afternoon will see an opening plenary session. Paul Degges, chief engineer, Tennessee DOT, will welcome delegates, and he will be followed by Mark McConnell, Mississippi DOT, on the TSP•2 program and pavement preservation, and Jean-François Corté, past secretary general of the World Road Association (PIARC), on social expectations of the highway system. A speaker from the private sector will discuss the impact of good roads on industry and timely deliveries.

Then, a panel on agencies and pavement preservation will feature Butch Waidelich, FHWA chief operating officer (invited), Brian Stacey, National Association of County Engineers, and regional Pavement Preservation Partnership chairs Francis Todey, Iowa DOT, Dean Dickinson, Connecticut DOT, Mary Gayle Padmos, Montana DOT, and Jon Wilcoxson, Kentucky Transportation Cabinet. The day will conclude with a welcoming reception.

WEDNESDAY, OCT. 12
Four concurrent sessions will be held Wednesday morning. Pavement Preservation Basics will be discussed by Mark Ishee, Ergon Asphalt & Emulsions, David Peshkin, Applied Pavement Technologies, and Dale Harrington, National Concrete Pavement Technology Center. Environmental Impacts of pavement preservation will be examined by John Warner, Warner...
Chip Seal or Fog Seal? Priming or Patching? Apples or Oranges?

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Babcock Institute, Marie Venner, Venner Consulting, and Todd Thomas of Colas North America.

Also Wednesday morning, Emerging Technologies will be covered by Andrea Latham, Keystone Engineering, James Tsai, Georgia Tech, and Don Matthews, Pavement Recycling Systems. And MAP-21 Asset Management and Pavement Performance Measures will be outlined by Pete Stephanos, FHWA, who will be followed by a panel including Eric Thibodeau, N.H. DOT, Francis Todey, Iowa DOT, Lloyd Neeley, Utah DOT, and Jon Wilcoxon, Kentucky TC.


Wednesday afternoon a field demonstration of pavement preservation techniques will take place at Nissan Stadium, home to the NFL Tennessee Titans. It will include live applications of a fog seal, scrub seal, microsurfacing, thin HMA overlay, and crack sealing treatment. Rigid pavement demonstrations, such as dowel bar load transfer retrofits and diamond grinding also will be shown.

Equipment displays will include a microsurfacing machine, cold milling machine, a chip seal aggregate spreader, an asphalt emulsion distributor, in-place recycling machine, crack router, and sealant melter. All of the demonstrated treatments will be in a secure, protected area, thereby avoiding need for traffic control, and affording the delegates maximum movement, flexibility, and opportunities to have questions answered.

THURSDAY, OCT. 13
Thursday will be very busy, with multiple tracks and concurrent presentations all day. Kicking off the morning will be Pavement Preservation Best Practices, with Jason Dietz, FHWA Resource Center; Scott Shuler, Colorado State University; and Larry Scofield, IGGA. Sustainable Case Studies will be explored by Kevin Donnelly, Western Emulsions; Becky McDaniel, Purdue University; and Brian Diefenderfer, Virginia Center for Transportation Innovation & Research.

At the same time will be Research: SPS-2/NCHRP 9-53 and 14-33, with Jeff Uhlmeyer, Washington State DOT, Gonzalo Rada, AMEC Foster Wheeler, and Chuck Schwartz, University of Maryland; and Pavement Condition Data for Preservation, with
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Tracy Novak, Kentucky TC, Rick Miller, Kansas DOT, and Geoff Hall, Maryland DOT.

Late morning concurrent sessions are Safety Initiatives, with Jesse Bhullar, Caltrans, Chris Wagner, FHWA Resource Center, and Cecil Jones, Diversified Engineering Services; Recycling & Reuse, with Don Matthews, Pavement Recycling Systems, Steve Cross, ARRA, and Mark Snyder, consultant; and New Measurement Technologies, with Kelvin Wang, Oklahoma State, Curt Beckemeyer, Applied Research Associates, and Edgar de Leon Izeppi, Virginia Tech.

Early Thursday afternoon sessions are Quality Measurement, with Jon Epps, Texas Transportation Institute, Bob Jerman, Ingevity, and Todd Shields, Indiana DOT; and Economics, with Doug Gransberg, Iowa State University, Susan Tighe, University of Waterloo, and David Hein, Applied Research Associates.

Efforts to Advance Preservation will include Dale Heglund, N.D. LTAP, Richard Domonkos, Indiana LTAP, Charles Goodspeed, N.H. LTAP, and Jim Nichols, Nevada LTAP; and Pavement Management: Putting the Data to Work, with Judith Corley-Lay, N.C. DOT, John Colplantz, Oregon DOT, and Scott Gibson, Washoe County, Nev.

Late Thursday sessions will be Advancing the Technologies, with Ed Naras, MassDOT, Scott Metcalf, Ergon Asphalt & Emulsions, and Robert Hogan, Caltrans; Societal Benefits & Implications, with Teresa Adams, University of Wisconsin, John Harvey of UC-Davis, and another panelist; NCAT and MnROAD Studies, with Buzz Powell, NCAT, Ben Worel, MnROAD, and Gary Hicks, CSU-Chico; and Decision Making, with David Luhr, Washington State DOT; Charles Pilson, AgileAssets; and Sui Tan, Bay Area MTC.

On Friday, Oct. 14, morning plenary sessions will include pavement preservation partnership meeting summaries, and an engaging VIP panel which will set the stage for the future as it tackles the NPPC 2016 theme Continuing the Drive for Change.

The 2016 conference offers an ideal venue for pavement preservation technology transfer, offering preservation practitioners across the country an opportunity to hear from experts in the preservation field, and to observe demonstrations of the placements of several types of pavement preservation treatments.

For more information, or to register, visit http://nationalpavement2016.org/.

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The partnership will provide research in preservation techniques for both flexible (bituminous) and rigid (portland cement concrete) pavements, and supply real-world accelerated pavement preservation performance testing in both hot and cold climates. By leveraging economies of scale, it may deliver research products for a larger base of supportive agencies and private sector clients at lower buy-in costs. The partnership has the potential to play a much larger role in the national effort to validate pavement performance. Sharing resources and expertise will improve coordination of experiments and expand evaluation of pavement performance in both northern and southern climates. Also, the collaboration permits testing of PCC pavements and the inclusion of the results in comprehensive research products, which is not possible when NCAT works on its own.

The NCAT test facility (left) has 46 different test sections on its 1.7-mile oval track, while the Minnesota DOT’s MnROAD facility track (right) consists of a 3.5-mile interstate (I-94) high-volume roadway, and a 2.5-mile closed loop low volume road simulating rural roads.

The goal of this new research is to quantify the life-extending benefits of different pavement preservation treatments for roadways in different stages of life and decay. Both facilities have a history of evaluating the performance of pavement preservation treatments, including chip sealing, micro surfacing, crack sealing and thin overlays.

Now, accelerated testing will provide unique opportunities to determine the field performance of breakthrough materials and pavement preservation concepts without the risk of failure that local and state agencies are unwilling to accept. To address the needs of northern and southern climates, similar test sections are being developed for both Alabama and Minnesota. Off-site test locations on existing roads and highways that can be easily monitored for both low and higher volume roadways are being established. Off-site concrete test sections in Minnesota may also be incorporated.

Please join your fellow stakeholders in pavement preservation by making a financial contribution to research at NCAT and MnROAD. For more information, contact FPI’s executive director Jim Moulthrop, P.E. (PA, AZ), (512) 979-8865, jim.moulthrop@gmail.com.
Planning and procurement are underway for the placement of northern pavement preservation sections in central Minnesota in July 2016.

MnROAD worked with state DOTs with a northern research focus to develop a consensus to utilize 2.1 miles of Mille Lacs County Road 8 as the low-traffic road, and U.S. 169 as the higher-traffic road, near Pease, Minn.

Both sections are located about 45 minutes north of the main MnROAD test site on I-94 near Albertville just north of Minneapolis. Martin Marietta Aggregate’s Waite Park granite will be the aggregate source and Flint Hills Resources will provide the asphalt emulsions.

Age and pretreatment condition of the existing pavement surfaces on County Road 8 and U.S. 169 were the primary factors in the selection process for both locations. The original treatments/combinations from Lee Road 159 will be placed in both locations in order to encompass the effects of thermal cracking and snow plow damage.

The objective to replicate the original southern research on Lee Road 159 in a northern climate was achieved, noting the same types of minor changes made in treatments and combinations prior to placement on U.S. 280 (i.e., refining the number and type of Thinlay sections).

Vance Brothers will be the placement contractor for the northern treatments just like they were for the southern treatments, which will eliminate the otherwise confounding effect of placement quality on performance.

Also, the Fall 2016 sponsor meeting will be held at MnROAD so funding partners can observe post treatment condition of all the low and high volume road treatments/combinations.

The sixth research cycle at the NCAT Pavement Test Track and the third phase of MnROAD research are for the first time engaged in a research partnership that is cooperatively funded by numerous state DOTs from all over the country for the purpose of executing a national long-term pavement preservation benefit experiment. The objective of this preservation group (PG15) experiment, in which FP2 is an equal funding partner, is to quantify the benefits of pavement preservation on both low volume and high volume roadways with results that are implementable in both northern and southern U.S. climates.

Performance of a comprehensive selection of treatments and combinations will for the first time be related to varying levels of pretreatment pavement condition in both hot and cold climates. This will equip agencies from all over the country to select future treatments that will provide the best life cycle investment for each individual roadway.

More information on the partnership and nationwide experiment it supports at http://www.dot.state.mn.us/mnroad/ncatpartnership/index.html

Tests in Southern Climate

The first preservation treatments were placed in select (100-ft., single-lane) sections on the NCAT Pavement Test Track in the spring 2014 after trigger levels of cracking (20 percent of the total lane area) were reached. A limited number of treatments and combinations were carefully selected for accelerated traffic testing on the track in order to ideally complement a larger number of low-traffic treatments and combinations that were placed off the track in summer 2012 on Lee Road 159 (a dead end access road to a quarry and asphalt plant).

Treatments were placed in 100-foot sections in both the inbound (lightly loaded) and outbound (heavily loaded) lanes. FP2’s participation in the design and execution of the 2012 experiment was key to the success of the overall effort.

At deadline in the middle of April 2016, approximately five million equivalent single axle loadings (ESALs) had been applied in an accelerated manner to select preservation treatments placed on the NCAT Track in spring 2014.

The performance (quantified with weekly performance measurements for roughness, rutting, macrotexture, and cracking) of all treatments and combinations has generally been very good on all three southern locations (the track, Lee Road 159, and U.S. 280). Crack sealing, scrub sealing, micro surface, cape sealing, and thin overlays all have demonstrated short-term life extending and condition improving benefits. Long-term data collection will quantify the full benefit of pavement preservation in a southern climate.

State highway agencies interested in participating in this pavement preservation and recycling research should contact either Ben Worel (Ben.Worel@dot.state.mn.us) at Minnesota DOT, or Buzz Powell (buzz@auburn.edu) at NCAT for more information.

Powell is assistant director and Test Track manager, National Center for Asphalt Technology, Auburn, Ala.
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The Federal Highway Administration and its many highway safety partners are addressing both infrastructure safety as well as driver performance issues. One element is to focus on the data and find roadway locations where severe crashes are overrepresented.

In 2013, there were approximately 5.6 million crashes reported across the nation, including 32,719 fatalities and more than 2.3 million injuries. More than half of the 2013 fatalities were roadway departure crashes.

Often, a small subset of the total highway network is responsible for a significant percentage of certain crash types. In 2008, for example, 28 percent of fatal crashes occurred on horizontal curves, yet horizontal curves make up only 5 percent of our nation’s roadways, which implies that crash fatalities that occur on curves are significantly overrepresented, and curves should be a specific area of focus for safety improvements.

Many states are making great efforts to improve safety on horizontal curves. Transportation agencies can work on a small percentage of curves and have a significant effect on highway safety if an effective countermeasure can be identified and applied. One of these countermeasures is the high friction surface treatment (HFST).

HIGH FRICTION SURFACE TREATMENTS

The innovative safety countermeasure that we call HFSTs began as a bridge deck preservation treatment in the U.S. in the 1950s. From there, it crossed the Atlantic and was adopted in the United Kingdom, where, in the late 1960s, it evolved into a safety treatment for curves and intersections.

HFSTs came back to the United States in the late 1990s as a safety treatment for curves and intersections when some local and state agencies began to try a few installations. Although there was no official evaluation at the time, anecdotal evidence showed that the benefit was a phenomenal reduction in crashes; however, as discussed in FHWA’s Public Roads magazine, these early installations were not very durable. In fact, some installations failed immediately after installation.
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The product did not seem to have consistency in either performance or in the specifications and methods used to apply the treatments. Early versions of HFSTs were being installed in the same way as a rigid bridge decking, varying by manufacturer’s guidance, or as a novelty product. While bridge deck preservation installations are similar, they are also very different when applied on an asphalt pavement in a severe curve. The shear loads applied to the HFST aggregate are greater in curves than a typical concrete bridge deck, and asphalt pavement provides less tensile strength. Also, asphalt pavement as the bonding substrate has greater variation in the texture.

For years, the process for applying HFST was strictly a manual operation, with a squeegee application of the binder, followed by various methods for placing aggregate into the binder. While some contractors still pursue these methods, many have pursued technology innovation to improve quality and to shorten the application process.

One solution uses self-contained trucks that distribute the polymer evenly in a measured amount and instantly applies the aggregate. The equipment measures the amount of material applied and makes a project record of how much product was installed. So far, three different application equipment designs have been developed and are in production. This year, more contractors are entering the ranks of those with innovative equipment who have successfully bid projects.

**SUBSTRATE PROVIDES STRENGTH**

HFST can be placed on asphalt pavement or concrete surfaces, but it is not intended to be used for continuous paving. HFST is an extremely thin overlay, 0.12 to 0.16 in. (3 to 4 mm), that relies on the substrate on which it is placed for structural strength.

HFST consists of two parts: a polymer binder and a special aggregate. The special aggregate is extremely polish-resistant, very hard, and produces very high friction values (often in the 80 to 90 range FN40R when tested in accordance to AASHTO T 242).

The best aggregate to provide this performance is artificial aggregate—calcined bauxite—that is commonly used by the refractory industry and for creating industrial abrasives. The refractory-grade bauxite is heated (calcined) to between 1600 and 1800 deg C (2912 to 3272 deg F). Calcination transforms the soft clay bauxite into a product just slightly softer than diamonds on the Mohs hardness scale.

This product is also much more consistent in quality than naturally mined aggregates, and it requires special crushers to produce the required gradation from such an extremely hard substance. In addition, the calcined bauxite final product has almost zero moisture content, and must be packaged to keep moisture content very low for installation with the polymer binder.

While the available before and after crash data have indicated HFST can make a curve or an intersection much safer, in many cases all but eliminating crashes, it really stands out where geometric friction demand is high. This site characteristic causes accelerated pavement polishing, which is the greatest contributor to roadway departure crashes at high-crash locations.

**DEPLOYMENT FACTORS**

As the technology improves, state DOTs are developing a strategy for deploying this product.

The highest crash reductions occur when HFSTs are applied in a location where crashes are related to wet conditions. In essence, those are locations with a marginal available pavement friction for the existing speeds and geometric conditions. The condition becomes critical when the pavement friction is further compromised by wet weather.

Even with very light rain, pavement can lose 20 to 30 percent of its friction. These critical locations tend to be on roadways with higher friction demand and where the predominant operating speeds are not consistent with the geometric design or operational use. This condition accelerates the pavement polishing at the curve.

Wet weather typically is the first notable emergence of a skid issue, but pavement friction only gets worse if untreated. In many cases, these locations cannot be treated successfully with traditional pavements because they polish quickly. HFSTs are the only long-term pavement solution that can reduce wet crashes and also help compensate for excessive geometric friction demand at these curve locations.

The primary factor that limits the life of an HFST installation at
present is the life of the pavement underneath. This is such an important longevity factor that states like Indiana are resurfacing first and then applying HFSTs in spots where traffic conditions, traffic speed, and geometric restrictions make HFSTs a good, cost-effective safety enhancement.

**HFST COST EFFECTIVENESS**

States that were early to adopt HFSTs have been performing crash evaluations and benefit-cost analyses to assess the successfulness and cost effectiveness of the applications.

One of the early leaders to deploy HFSTs on a large number of projects was the Kentucky Transportation Cabinet (KYTC), the early work of which has benefited many states that later adopted HFST as a safety countermeasure.

One of the very early projects in Kentucky was a curve on a two-lane road where 900 sq. yd. of HFST was installed in August 2009. In the three years prior to the HFST installation, this small curve had a total of 53 wet road crashes and three dry road crashes, some of which were fatal. But after the installation, this location averaged less than one crash per year, and none have been fatal.

In terms of cost effectiveness, KYTC indicated in 2013 that the crashes reduced at that one curve had paid for all the HFST projects that had been installed in Kentucky to date, which were around 100 curves at that time. In a June 2015 evaluation of 69 curve projects with at least three years of post-installation history, KYTC found those curves averaged a total reduction of 235 crashes per year, an 87 percent reduction.

South Carolina began its HFST experience with an experimental product evaluation that allowed the installation of six projects of varying sizes. Their first project was installed in October 2008. SC DOT realized a crash reduction of 70 percent with an associated benefit:cost ratio of 23:8. However, the greatest cost savings came when the agency used HFST on U.S. 25 to address existing conditions, which were beyond normal pavement polishing. Although they had determined the section of road needed to be constructed, funds were not available for such a major improvement. However, with HFST, SC DOT had a treatment option that was not previously available, and the state was able to save millions of dollars in reconstruction costs.

A recent study to evaluate the HFST installations in Florida reported a 32 percent reduction in total crashes with a calculated benefit:cost ratio of 26 for projects with curves with less than a 1,000-ft. radius.

Like South Carolina, Caltrans opted to use HFST instead of reconstructing a curve in a difficult location. The agency had made every effort to reduce crashes by installing the standard safety countermeasures, but nothing was affecting the crash pattern. To make matters worse, the location was in a pristine environment, and the curve reconstruction would have inconvenienced the traveling public with an extensive detour.
for a long period of time. However, to-date the HFST application seems to have solved the safety issues, saved millions of dollars, had minimal traffic disruptions, and did not endanger the environment.

Another benefit observed from the use of HFST is improved traffic operations. A reduction in crashes at critical sections of roadway like ramps always helps relieve congestion. This congestion relief is even greater when the reduction in crashes includes trucks, as they tend to take longer to clear.

Although the locations for treatment are selected based on crash severity and frequency, project locations only occasionally coincide with the locations that are over-represented by truck crashes. However, the application of HFST on urban ramps that are prone to truck crashes offers a potential solution to help traffic congestion in these areas.

**FUTURE OF HFSTS**

Even though the AASHTO Provisional High Friction Surface Standard Specifications is available as guidance for state DOTs in developing their own standard specifications, it is focused on materials, so there is still a need to develop a specification tied to improving quality, product consistency, and installation longevity.

In addition, the balance between risk and oversight must focus on measuring the critical elements that control quality. As a result, there is an immediate need for the industry to develop a performance specification. It is still early days yet, but FHWA and various state agencies are working to resolve many concerns, including requiring more training for inspectors, as HFST is different from the traditional pavement projects that most inspectors encounter.

FHWA is currently researching and evaluating the use of calcined bauxite with polymer modified asphalt. This potential product can be classified as a method for “enhancing friction,” as the purpose here is not to obtain extremely high friction values, but to improve the resistance of the road surface to pavement polishing.

While high-friction-demand curves will always require a product with a binder with high tensile strength, as is commonly used today, many of the less severe curve locations in the U.S. could be improved with an alternative treatment.

Although HFST would work on these curves, the cost to apply HFST may be prohibitive. By reducing the price significantly through the use of a less costly binder in locations with a lower friction demand, HFST can be more widely deployed, especially on local roads, which often have shallow pavement structure and may not be in excellent condition. With the polymer modified asphalt binder, a less costly solution of enhanced friction treatment will be available to reduce roadway departure crashes on these local roadways, which are by far the most numerous conditions in the United States.

Cheung and Julian are affiliated with the Office of Safety, Federal Highway Administration.
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Lately last year, the Fixing America’s Surface Transportation Act, or the FAST Act, was signed into law.

The FAST Act is a five-year, $305 billion surface transportation reauthorization which builds upon many of the policy goals established in MAP-21, its predecessor legislation, including clarification of pavement preservation’s eligibility for funding in major programs such as the National Highway Performance program. It also added new programs such as the new Nationally Significant Freight & Highway Projects Program.

The new law increases funding for formula programs for surface transportation projects by over 2 percent per year. The five-year FAST Act provides the funding certainty needed for states and local governments to plan longer term pavement and asset management strategies.

**Preservation ‘Up Front’**

As state and local governments move forward in developing asset management plans—determining how they will utilize new program funds and generally develop their plans for the next five years—pavement preservation needs to remain “top of mind” or “up front”. What is the best way to do this?

In addition to remaining close to state and local transportation decision makers, it’s imperative that your federal policymakers be informed about pavement preservation. In election years, such as 2016, when all U.S. House of Representatives and a third of the Senate are up for re-election, members tend to spend much more time working in their districts and states. Members of both chambers will be in their districts during key periods of time for the industry such as between May 30-June 3, July 18 through Labor Day, Sept. 5, and again from Oct. 10 to Nov. 8.

While in their districts, members meet with constituents, meet with employers in their districts, and take time to learn first-hand about the industries that drive their local economies. Developing a relationship with your members of Congress, helping them learn more about your business, and educating them about the benefits of pavement preservation is a valuable service you can provide to your congressman and two senators who represent your business.

**Reaching Out to Congress**

While education can, and does happen in Washington—spurred by FP² and its outreach efforts—seeing and learning first-hand can be very helpful to members of Congress and the industry, particularly when members come to the table with little experience about a particular industry.

Believe it or not, members are interested in sitting down and speaking with executives and workers from businesses in their district, touring facilities and plants, and participating in openings or ribbon cuttings. They enjoy coming to your facility, but they also hold meetings in their district offices. The best way to arrange a meeting is to look at the official website of your representative and senators.

Most offices have a district scheduler and/or chief of staff. If not, a call to the main number in Washington with an explanation of what you want to do will ensure you are put in touch with the correct staff person.

Once you have identified the appropriate person, email him or her a short invitation or meeting request for a specific date in the future; a month in advance is usually good. Keep in mind, aside from the dates noted above, members are more apt to be in their states or districts Friday through Monday.

An invitation should contain the name of your company with an explanation of what you do, and a short description of what you are inviting them to do. Or, if you are requesting a meeting, state what you want to speak with them about.

A typical meeting with a member and/or key staff will often last under 30 minutes and a visit, depending on what you do, may last an hour. Ideally you will have the opportunity to talk about your company and what it does, how many people the company employs seasonally and year around, how your work benefits the public by discussing the improvements in road quality and cost savings that can be attained through the pavement preservation work you do. Also state how a long-term highway bill and inclusion of pavement preservation is critical to your business and any other federal policy that impacts your business. Visit FP².org for hints on how to conduct a congressional visit.

When the meeting or visit is over, don’t forget to thank the staff, and keep in touch by sending press releases or other pertinent information that you believe might be of interest to them on pavement preservation. Let FP² executive director Jim Moulthrop know of your meeting and visit so FP² can reinforce your message with the representative’s Washington office. Finally, now that you have started this relationship, be sure you maintain!

Taylor is principal at FP²’s legislative counsel, Williams & Jensen PLLC.
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The 2016 World of Asphalt Show & Conference and AGG1 Academy & Expo—held in Nashville March 22–24—was the most successful ever, and FP² and its allies were there. Record registered attendance of more than 9,000 was 18 percent over the record-setting 2015 shows, with 38 percent growth compared to 2013. Pavement preservation was on the educational program, and many supporters of FP² Inc. from industry exhibited. Here’s a look at pavement preservation at World of Asphalt.

Moulthrop Honored by AAPT. In mid-March the Association of Asphalt Paving Technologists (AAPT) awarded FP² executive director Jim Moulthrop with an honorary membership “for outstanding eminence in asphalt paving technology.” Moulthrop (center, with Dr. R. Gary Hicks and AAPT president Dr. Geoffrey Rowe) was recognized along with Gerry Huber of Heritage Research Group. They are among 36 honorary members chosen since AAPT was founded in 1924.
Over 350 attendees from over 150 of the world’s leading companies in the pavement preservation and rehabilitation industries came to southwest Florida for the 13th combined annual meetings of FP2 Inc. founding associations, the Asphalt Emulsion Manufacturers Association (AEMA 43rd annual meeting), Asphalt Recycling & Reclaiming Association (ARRA 40th annual meeting), and the International Slurry Surfacing Association (ISSA 54th annual convention).

Held Feb. 23–26 in Bonita Springs, the convocation heard more than 30 speakers over the four-day period, highlighting new technologies in asphalt emulsions, asphalt recycling and reclaiming, slurry and micro surfacing, chip seal and crack treatments.

Pavement preservation was front and foremost at the event, with presentations by FP2 Inc. executive director Jim Moulthrop, P.E., National Center for Pavement Preservation director Larry Galehouse, P.E., and Dr. Buzz Powell, P.E., assistant director, National Center for Asphalt Technology, who updated delegates on preservation testing as the NCAT Pavement Test Track and at MnROAD this summer. And FP2’s legislative counsel, Tracy D. Taylor, Williams & Jensen, updated delegates on the new FAST Act surface transportation reauthorization, and other “inside the Beltway” affairs.

ARRA re-elected Ryan Essex president. AEMA re-elected Archie Reynolds president. AEMA’s immediate past president is Mark McCollough, Asphalt Materials Inc. Directors elected for the term include Greg Arntson, Albina Fuel Co., Bob Huit, Russell Standard Corp., Arlis Kadrmas, BASF Corp., Matt Kennedy, McAsphalt Industries, Ltd., Dan Koeninger, Terry Asphalt Materials, Inc., and Craig Moore, Cleveland Asphalt Products. Etienne LeBoutetier, Colas S.A., France, will serve as international member representative, and Todd Ryne will continue as AEMA’s supplier member representative. Mike Hemsley, Paragon Technical Services, was reappointed chair of AEMA’s International Technical Committee.

Essex Continues as ARRA president. Essex re-elected for the 2016-2017 term. He’s vice president of Miller Paving Ltd., of Gormley, Ont. Other 2016–2017 officers elected were vice president, Darren Coughlin, Coughlin Company, and secretary/treasurer Ron Wilson, Dustrol, Inc. ARRA’s immediate past president is Pat Faster, Gallagher Asphalt Corp.


Price to continue at ISSA. Other 2016-2017 officers elected were vice president, Mark Ishee, Ergon Asphalt & Emulsions, Inc. and secretary/treasurer Todd Ryne, Akzo Nobel Surface Chemistry. AEMA’s immediate past president is Mark McCollough, Asphalt Materials Inc. Directors elected for the term include Greg Arntson, Albina Fuel Co., Bob Huit, Russell Standard Corp., Arlis Kadrmas, BASF Corp., Matt Kennedy, McAsphalt Industries, Ltd., Dan Koeninger, Terry Asphalt Materials, Inc., and Craig Moore, Cleveland Asphalt Products. Etienne LeBouteiller, Colas S.A., France, will serve as international member representative, and Todd Ryne will continue as AEMA’s supplier member representative. Mike Hemsley, Paragon Technical Services, was reappointed chair of AEMA’s International Technical Committee.

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Price to continue at ISSA. And the membership of ISSA re-elected Rusty Price president for the 2016-2017 term. He’s operations manager for Utah-based Intermountain Slurry Seal.

Other officers re-elected for 2016-2017 are vice president

ARRA re-elected Ryan Essex as president

AEMA re-elected Archie Reynolds president
Carter Dabney, Slurry Pavers, Inc., secretary Rex Eberly, Bergkamp Inc., and treasurer Eric Reimschiissel, American Pavement Preservation. ISSA’s immediate past president is Christine Deneuvillers, VECTRA, France.

Directors elected for the term include Chris Anspaugh, Strawser Construction Inc., Doug Hogue, VSS Macropaver, Sabine Lebec, Eurovia, Steve Olsen, Telfer Highway Technologies, Howie Snyder, Vance Brothers, Inc., Larry Tomkins, Ergon Asphalt & Emulsions Inc., and Dave Welborn, Ingevity. Ingevity’s Bob Jerman was re-elected ISSA’s technical director.

These three important associations will be holding noteworthy events in the coming months. These include:

- **International Symposium on Asphalt Emulsion Technology**, Nov. 1–4, Crystal City, Va., http://ppralliance.org/event/2016-aema-isaet/

Keeping warm on cool subtropical evening are Marilyn and Roger McCullough, Southwest Slurry Seal, Inc.

Delegates gather for lively opening session

Sea breeze, palms and stars set stage for fabulous evening at Hyatt Regency Coconut Point Resort & Spa

Cogito Ergon Sum: At morning break are Baxter Burns, Ryan Proctor, Tom Flowers and Myles McKennie, Ergon Asphalt & Emulsions

At opening reception are Doug Hogue and John Birchall, VSS Macropaver, and ARRA’s technical director Steve Cross

Enjoying the evening are Nelson Wesenberg, Colas Solutions, Dan Koeninger, Terry Asphalt, and Daniel Guay, Emulsion Products

At coffee break are FP2’s Jim Moulthrop, Asphalt Institute’s Pete Grass, and NCAT Test Track’s Buzz Powell
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A metropolitan planning organization (MPO) is a federally required transportation planning body—essentially a council of governments—composed of elected and appointed officials representing local, state and federal governments or agencies having interest or responsibility in transportation planning and programming.

Each urbanized area in the United States with a population of 50,000 or more is required by the federal government to have a metropolitan planning organization. The MPO discusses and votes on multi-modal transportation issues of region-wide significance, and decides which local transportation projects should be implemented.

When I researched this topic for a presentation at the Pavement Preservation Expert Task Group meeting in 2010, there were 382 MPOs in the United States, including 52 representing regions with populations of more than one million people. As you might imagine, most of these urbanized regions have substantial investments in roadway networks.

As an example, the Metropolitan Transportation Commission (MTC) in the San Francisco Bay area of California represents 7.1 million people and 42,000 lane-miles of roadways, including 1,500 miles of highways. The replacement value of its transportation assets has been estimated at between $40 billion and $50 billion.

They devised a pavement management system for use by member agencies to track roadway conditions, and help protect the regional investment. Over time, all 109 of the local jurisdictions have adopted the use of the now-famous Street Saver pavement management system.

The MTC has certified data collection companies to assure consistently good data, and with the uniform data analysis package in Street Saver, every jurisdiction’s roads are evaluated and transparently compared on an apples-to-apples basis. As a result of good data and analysis, the MTC sets preservation goals for each local agency to accomplish, and it ties a portion of its funding distribution to the successful completion of those goals. The MTC has a model program that should be emulated by other MPOs across the nation.

DENVER AREA FIGHTS ‘WORST FIRST’

In the Denver area, we have a long way to go. In the early 1990s as the Pavement Management Engineer for the City of Aurora, Colo., I helped organize a group called the Metropolitan Government Pavement Engineer’s Council (MGPEC). The group has met monthly for more than 20 years, and has developed a series of standards and pavement design and construction specifications that are useful to local agencies throughout our region.

It is interesting to note that the local agencies in the Denver area use more asphalt than does the Colorado DOT statewide. As the needs of the local roadways are different than the needs of the more heavily trafficked state routes, it is not surprising that there are some differences in the specifications.

Last year, Mike Skinner, now director of pavement engineering for the Colorado Asphalt Pavement Association, and I requested the formation of a Transportation Asset Management Task Force by the MGPEC, and we were appointed as co-chairs. One of the primary goals of our task force is to assist our MPO—the Denver Regional Council of Governments (DRCOG)—with the implementation of asset management programs by the 54 local agencies in the Denver-metropolitan region and by DRCOG.

As our task force reviewed the criteria for project selection utilizing the federal funding that passes through DRCOG, we discovered a written worst-first selection process. Projects that are funded must score lower than a “40” in a very limited pavement evaluation computer program.

Last fall we met with the staff at DRCOG to share MGPEC’s concern about this worst-first criteria and its impact on their transportation asset management program. We explained that the MAP-21 performance goals will not be satisfied without an emphasis on pavement preservation.

We will be meeting with the Technical Advisory Committee at DRCOG this year, working to implement a pavement preservation philosophy throughout the coming year in the Denver region.

I want to encourage my friends and colleagues in the preservation community to examine the funding criteria for pavement projects that are used by the MPOs in their areas. Getting the MPOs to incorporate pavement preservation funding can be a key for local agencies improving their management of our transportation assets. Everyone wants good roads, but areas that have worst-first funding criteria will never have them. 

Mueller is president and CEO, Stephen Mueller Consultancy
The City of Visalia, Calif., is the winner of the 2015 Project of the Year Award from WRAPP, the Western Region Association for Pavement Preservation (WRAPP), formerly the California Chip Seal Association.

In 2015, this program encompassed over 1.7 million sq. yd. of surface treatment applications. Intermountain Slurry Seal, Elk Grove, Calif., was the prime contractor, and Talley Oil Co., Madera, was the subcontractor and applicator on the project. Cain Trucking, Tulare, handled off-site product storage and just-in-time delivery of pavement rejuvenator Reclamite emulsion for the project, shipping from Bakersfield to the Visalia area. Visalia’s Jose Herrera, project supervisor, oversaw the project for the city, and public works director Norm Goldstrom, P.E., packaged the project based on PCI and historical findings.

In 2011, Visalia began exploring suitable pavement management systems (PMS) to utilize and monitor street pavement condition indexes (PCIs). The program chosen was Lucity software by IMS (Infrastructure Management Systems). The system was put into place and was ready for applications of various surface treatment methods and applications by 2013.

Generally pavement management programs do not include asphalt rejuvenators within their software due to lack of that knowledge by the program developers, and legacy utilization of historical chip seal or slurry wear course treatments. The City of Visalia goal was to maintain the high street PCIs shown by the PMS program with a lower cost treatment, extending pavement life four to five years.

Tricor Refining—producer of Reclamite asphalt rejuvenator—assisted with viewing the road network and placing ring tests for product absorption on the pavements in the program. The application rate varied between 0.07 to 0.10 gal per sq. yd. of the Reclamite emulsion diluted with water 2:1. The job was to maximize the absorption of the rejuvenator, then allow it to cure for a minimum one to two hours, followed by sanding and mechanical sweeping within the same day or within a 24 hour period.

Within the rejuvenator seal project specification was the performance requirement to meet minimum changes in penetration and viscosity and/or changes in the dynamic shear rheometer testing, which measures the stiffness of the asphalt or the complex modulus “G”.

Penetration and viscosity testing utilizing Caltrans test methods and DSR testing showed substantial improvement in penetration and viscosity, leading to reduced stiffness of the binder retarding the aging process. That improvement was in the 1200 to 1600 percentile range.

The City of Visalia and Norm Goldstrom’s engineering group have increased PCIs on Visalia streets, and raised the level of public awareness to pavement preservation though an excellent in-house media promotion. The city’s plans to continue utilizing preservation methods promoted through the California Chip Seal Association, now WRAPP.
The University of Arkansas is developing a research group for pavement maintenance and pavement rehabilitation products, and student involvement is introducing pavement preservation concepts to a new generation.

The private sector has been very supportive of advancing this research program. One of the first tasks of this research group was developing the capabilities to make asphalt emulsions in the lab. Erica Yeung, current graduate student, began her master’s work in August 2015 and is in the process of finalizing her research proposal, which examines the interaction between asphalt emulsion and recycled asphalt pavement (RAP) reactivity.

After spending one summer working in an industry asphalt emulsion lab, she has strong expertise in fabricating asphalt emulsion at a lab scale. This is very important, as most university laboratories rely solely on industry to provide asphalt emulsion samples, so they have little control over the emulsion formulation, and all of the emulsions must be shipped before use.

Therefore, Yeung’s first task as a graduate student was getting the bench-top scale Herbert Rink asphalt emulsion mill up-and-running. Next, she will be crushing RAP in the lab, and understanding how (if any) charge is built on the RAP during the crushing process.

By utilizing different types of asphalt emulsions (with different emulsifiers), she will be able to determine how the asphalt emulsion interacts with different levels of charged RAP. This will be quantified by compacting the cold-In-place recycling (CIR) samples in a Superpave gyratory compactor. In theory, the faster the breaking of the emulsion, the harder it will be to compact. While this study is still in the early stages, it should provide some much needed understanding of how asphalt emulsion interacts with charged aggregate, and if that relationship changes over time with milled roadways.
In addition to fabricating asphalt emulsion in the lab and studying different formulations and RAP reactivity, the project also examined how labs could potentially reduce the amount of material required for lab evaluation. Obtaining the proper amount of field samples for a full lab evaluation requires a tremendous amount of material. Yet the University of Arkansas is chronically short of storage space for materials, and buckets line every open area of space around the lab. Therefore, it would be tremendously useful if the amount of material necessary to understand the behavior of a material could be reduced.

Therefore, graduate student Alex Jackson examined three tests of varying physical size that captured the creep behavior of CIR (which is indirectly related to the potential to crack). In order to properly scale-down the samples, three different gradations were explored to see if samples would behave simply as if they were “shrunk” down to size, which reduces the potential issues associated with single pieces of RAP spanning the entire sample (this is officially called maintaining a representative volume element).

The research found that the smallest test configuration was able to capture the same differences between materials and temperatures as the largest test configuration, using only 1 percent of the materials by volume. So it appears to be possible to gain an understanding of cracking of CIR by only using a fraction of the material usually necessary for performance testing.

These research projects—including others involving full-depth recycling—are hopefully just the beginning of research in pavement preservation, pavement maintenance and pavement preservation at the University of Arkansas. To learn more, visit our website at www.andrewbraham.com

Braham is assistant professor, Department of Civil Engineering, University of Arkansas-Fayetteville

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