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TxDOT

TEXAS PAVEMENT PRESERVATION CENTER

# TEXAS PAVEMENT PRESERVATION CENTER FOUR-YEAR SUMMARY REPORT

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CENTER FOR TRANSPORTATION RESEARCH
BUREAU OF ENGINEERING RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

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HTTP://WWW.UTEXAS.EDU/RESEARCH/TPPC/

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**TEXAS PAVEMENT PRESERVATION CENTER (TPPC)**

**About the Center**

The Texas Pavement Preservation Center (TPPC), in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, promotes the use of pavement preservation maintenance strategies in order to allow highway agencies to adopt cost-effective and efficient programs to sustain roadways and extend pavement service life. The concept of pavement preservation focuses on dealing proactively with pavements still in good to fair condition rather than reacting to pavements in poor condition. Historically, federal highway funding focused primarily on new construction and states were held responsible for all subsequent maintenance. Since 1976, there has been a trend allowing states to use federal funds for highway maintenance that extends pavement life, thus raising the role of this activity in agency operations and subsequently the budget.

If the correct treatment is applied at the right time, then pavement preservation offers a way to lengthen the service life of pavement, ultimately saving money because it delays costly rehabilitation or reconstruction activities. The many benefits of such a strategy include increased return on investment, extended service life, improved customer satisfaction, expedited treatment turn-around time, increased productivity, and enhanced pavement performance.

With pavement preservation, the service life of a roadway can exceed its initial design life and operate at a high level of user satisfaction. In fact, there can be up to a 10 to 1 return on money spent on preservation versus rehabilitation or reconstruction programs; or rather, every $1 spent in preservation eliminates or delays spending $10 on rehabilitation or reconstruction later.

Pavement preservation requires a customer-focused program to provide and maintain serviceable roadways, in a cost-effective and timely manner, encompassing preventive and corrective maintenance as well as minor rehabilitation. One of the challenges of pavement preservation is in determining the right maintenance or construction operations at the right time on appropriate roads. Choosing a road that is in fair condition without structural damage is important, and then choosing the best, most cost-effective technique among the many choices is essential for proper life enhancement. Consideration should be given to geographic and environmental conditions, existing pavement materials, and local traffic patterns.

The Maintenance and Design Divisions of the Texas Department of Transportation (TxDOT) created the first Preventive Maintenance Program. Preventive maintenance is a tool for pavement preservation. Non-structural treatments are applied early in the life of a pavement to delay deterioration. This program mandated the use of $115 million per year for seal coats, thin overlays, crack sealing, micro-surfacing, concrete pavement repairs and bridge preventive maintenance projects. The program has grown to about

$325 million per year. Because of the size of TxDOT's preventive maintenance program and the historical support for pavement preservation, Texas was a logical choice for the development of the Texas Pavement Preservation Center.

**Our Mission**

Established August 11, 2005, The TPPC serves the broad range of needs of the Texas Department of Transportation (TxDOT), and other agencies within the highway community by promoting awareness of pavement preservation as a feasible and practical maintenance strategy, providing training in preservation methods, operating as a source of knowledge for new techniques and procedures in this area, and supporting a long-term pavement performance approach. The TPPC has been actively involved in promoting awareness of pavement preservation methods at the state, national, and international levels for the past four years, which the following summary of TPPC projects and activities should serve to clearly demonstrate.

**Personnel**

Dr. Yetkin Yildirim is the Director of the TPPC, which is a collaboration between the Center for Transportation Research (CTR) and the Texas Transportation Institute (TTI). Dr. Yetkin Yildirim and Dr. Kenneth H. Stokoe represent the CTR, while Cindy Estakhri and Joe Button represent the TTI. The Center has been working closely with the Foundation for Pavement Preservation to attract industry attention to the center. The TPPC Board of Directors is made up of nine (9) members from TxDOT and five (5) members from the pavement industry.

TPPC TxDOT board members include Michael W. Alford, P.E., Ray L. Belk, SPHR, Gary D. Charlton, P.E., Tracy Cumby, Toribio Garza, Jr., P.E., Randy R. King, Paul Montgomery, P.E., Tammy B. Sims, P.E., J. Jeffrey Seiders, Jr., P.E. Industry leaders are also represented on the TPPC Board of Directors. TPPC industry board members include Joe S. Graff, P.E. of Halcrow Group, Bill O'Leary of Martin Asphalt Company, Kevin King of TXI Expanded Shale and Clay, Barry Dunn of Viking Construction, Inc., and Myles McKemie of Ergon, Inc. TPPC instructors also include Gerald D. Peterson and Joe S. Graff, P.E.

**Training Courses**

One of the primary goals of the Texas Pavement Preservation Center is education. By raising awareness of pavement preservation practices, the TPPC hopes to inform both engineers and policy-makers of the most effective options for highway maintenance that are currently available. Courses on Seal Coat Application and Inspection, Seal Coat Planning and Design, and Microsurfacing were offered by the TPPC to meet the needs of TxDOT and other partner organizations. These district-level training courses, designed by the TPPC, provide valuable instruction on the latest pavement preservation techniques and offer hands-on experience to a wide audience of engineers and technicians.

The Texas Pavement Preservation Center also makes training materials available to the wider public, through a series of free online courses. These user-friendly instructional materials serve to promote the awareness of pavement preservation practices by making the latest highway maintenance research easily available to students, highway engineers, researchers, and policy makers alike.

In the past four years, the TPPC has posted 56 lectures online at http://www.utexas.edu/research/tppc/conf/index.html, with topics ranging from HMA mix selection to seal coat aggregate types. Lectures from various pavement preservation seminars and seal coat conferences are gathered in these online courses, making the TPPC website a valuable resource for the survey and evaluation of current pavement preservation practices.

Also, in partnership with the Center for Lifelong Engineering Education at the University of Texas, the TPPC offers an online seminar for professional certification:

http://lifelong.engr.utexas.edu/shortcourse.cfm?course_num=1047

This online pavement preservation seminar offers participants an arsenal of pavement preservation best practices that will allow them to assess each situation and determine the appropriate pavement maintenance treatment. Since 2005, 255 Continuing Education Units (CEUs) and certificates have been awarded through the completion of this online seminar.

**Publications and Research**

The TPPC webpage not only offers these training materials, but serves as an outlet for the dissemination of pavement preservation research. Newsletters, research reports, and conference presentations are made available online, attracting many visitors to the TPPC website. Furthermore, the Pavement Preservation Journal attracts technical papers and research from around the world in the area of pavement preservation, and the technical papers are edited by the TPPC.

The TPPC has been conducting research on pavement preservation methods such as crack sealing, micro surfacing and slurry seal, seal coats, thin asphalt overlays, and fog seals for the past four years. The center has consistently published research reports through CTR at UT Austin and TTI at Texas A&M, and twenty-two technical papers have been selected by high quality national journals. Additionally, the TPPC has organized eleven presentations for national and international pavement preservation meetings in order to inform the broader highway community of its research results. The TPPC has been present at the annual meetings of the Transportation Research Board of the National Academies and the International Conference on Asphalt Pavement, attended various national pavement preservation task force groups, and actively participated in program developments. Since 2005, the TPPC has also hosted annual

Pavement Preservation Seminars that provide attendees with an excellent overview of the concepts, techniques, and materials involved in pavement preservation.

**Outreach and Education**

The TPPC has also been involved with various outreach and education projects to provide pavement preservation information to the traveling public. Through a partnership with the Engineering Education Research Center, the Texas Pavement Preservation Center has been able to collaborate with local high school students in the development of pavement-related science fair projects.

http://uts.cc.utexas.edu/~cosmos/index.html

Such a partnership provides local students with the opportunity to engage in challenging extra-curricular research at a nationally ranked university, while increasing public awareness of the essential practices of pavement preservation. Students sponsored by the Texas Pavement Preservation Center have continued to compete in the International Sustainable World (Environment, Energy, Engineering) Project Olympiad, an international science fair held in Houston, TX.

www.isweep.org

By supervising students these students as they develop and complete their science fair projects, the TPPC continues to pursue its mission to promote awareness of pavement preservation as feasible and practical maintenance strategy.

**Newsletters**

The following report compiles the first fifteen newsletters published by the Texas Pavement Preservation Center. These newsletters include summaries and reports from various pavement preservation seminars and conferences over the past four years, including TRB annual meetings, TxAPA Seal Coat Conferences, the 10th Annual International Conference on Asphalt Pavement, the International Slurry Surfacing Association Workshop, and the Transportation System Preservation Research and Implementation Roadmap Workshop. This collection of information prepared by the TPPC provides a comprehensive overview of the work of the Center and the present state of the pavement preservation industry.

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COLLEGE OF ENGINEERING
TxDOT
TEXAS PAVEMENT PRESERVATION CENTER
Newsletter
ISSUE 1 / WINTER 2006

## Issue 1, Winter 2006

## Inside this Issue



## TPPC Vision and Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost.

## Contact Us

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## Texas Pavement Preservation Center

The new Texas Pavement Preservation Center (TPPC) was officially established August 11, 2005 in joint partnership with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University.

## 2005 Pavement Preservation Seminar

The 2005 Pavement Preservation Seminar was held on October 4, 2005 at the Austin Convention Center in conjunction with the Texas Association of General Contractors Trade and Equipment Show. Sponsors for the Seminar were $FP^2$, Asphalt Emulsion Manufacturers Association, Associated General Contractors of Texas, the Center for Transportation Research, and the Center for Lifelong Engineering Education. Approximately 150 people from governmental and state agencies, professionals from industry, and academia attended the seminar. The seminar gave attendees an excellent overview of the concepts, techniques and materials involved in Pavement Preservation. The UT College of Engineering offered Continuing Education Units (CEUs) and a Certification of Completion for attendance. The program included the following presentations:

- **Asphalt Overlays**
  Gary Fitts, Asphalt Institute; San Antonio, TX
- **Scrub Seal & Fog Seals**
  Steve Douglas, Ergon Asphalt/Western Emulsions, Inc.
- **Crack Sealing Techniques and Materials**
  Vern Thompson, Crafco; Chandler, AZ
- **Chip Seal/Best Practices**
  Kevin King, TXI; Tyler, TX
- **TxDOT Questions/Discussions**
  Joe Graff, TxDOT; Austin, TX
- **Hot-In-Place Recycling**
  John Rathbun, Cutler Repaving; Lawrence, KS
- **Micro-Surfacing and Slurry Seals**
  Barry Dunn, Viking Construction; Georgetown, TX
- **Pavement Management Systems**
  David Peshkin, Applied Pavement Technology, Inc.; Downers Grove, IL
- **City of Los Angeles Pavement Preservation Program**
  Bill Robertson, Director and Nazario Sauceda, Assistant Director; City of Los Angeles, Department of Public Works, Bureau of Street Services

## First National Conference on Roadway Pavement Preservation

Transportation Research Board (TRB), a division of the National Research Council that serves as an independent advisor to the federal government on scientific and technical questions of national importance, organized the First National Conference on Roadway Pavement Preservation in conjunction with joint sessions. The conference was held in Kansas City, Missouri on October 31-November 3, 2005. The First National Conference on Roadway Pavement Preservation addressed all aspects of successfully implemented roadway pavement preservation activities, including management, engineering, economics, the establishment of strategic performance goals, and the implementation of routine maintenance, preventive maintenance, and minor rehabilitation activities.

## Texas Pavement Preservation Center

The new Texas Pavement Preservation Center (TPPC) was officially established August 11, 2005 in joint partnership with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University. The TPPC will provide training in the area of pavement preservation and act as a clearinghouse to publicize and distribute information on the latest advances in the pavement preservation field. TPPC will also provide expert demonstrations and on-site training, as needed or directed by TxDOT. TPPC is currently building a web site, which will present an online, quarterly newsletter to the maintenance community with information on research projects, training materials, journals, and conferences. TPPC will be a source of information related to recent developments in the area of pavement preservation.

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Section Chairs: Bill O'Leary and Yetkin Yildirim

For more information on the seminar and presentations please contact Dr. Yetkin Yildirim.

- Asphalt Overlays
  *Gary Fitts, Asphalt Institute; San Antonio, TX*
- Scrub Seal & Fog Seals
  *Steve Douglas, Ergon Asphalt/Western Emulsions, Inc.*
- Crack Sealing Techniques and Materials
  *Vern Thompson, Crafco; Chandler, AZ*
- Chip Seal/Best Practices
  *Kevin King, TXI; Tyler, TX*
- TxDOT Questions/Discussions
- *Joe Graff, TxDOT; Austin, TX*
- Hot-In-Place Recycling
  *John Rathbun, Cutler Repaving; Lawrence, KS*
- Micro-Surfacing and Slurry Seals
  *Barry Dunn, Viking Construction; Georgetown, TX*
- Pavement Management Systems
  *David Peshkin, Applied Pavement Technology, Inc.; Downers Grove, IL*
- City of Los Angeles Pavement Preservation Program *Bill Robertson, Director and Nazario Sauceda, Assistant Director; City of Los Angeles, Department of Public Works, Bureau of Street Services*

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***Asphalt Overlays* - Gary Fitts, Asphalt Institute; San Antonio, TX**

Fitts presented on the proper methods for thin HMA overlays for pavement preservation. A thin HMA overlay is an HMA application that is not intended to strengthen the pavement structure and is used to address functional problems. A thin HMA overlay is a surface replacement ("mill and fill") and is defined, according to Fitts, as less than 1 ½ inch of compacted thickness. Thin HMA overlays are used for the preservation of existing pavement and for functional improvements in surface friction, ride quality, and surface drainage. Fitts demonstrated how not to let the fresh HMA segregate, but the condition of existing pavement and construction quality directly affects the performance of thin overlays. Regarding surface preparation, Fitts recommended not to use "prime oils" such as MC-30 or AEP as a tack coat material. When truck loading, drop bulk loads of HMA in three piles: first in the front, secondly in the back, and lastly in middle. Regarding the HMA delivery process, Fitts advised never to let fresh HMA cool by stockpiling it onto the ground, never to bump the paver with the HMA-loaded truck, break the load before opening the tailgate, and charge the hopper before it is close to being empty. For the best performance, there must be an even compaction of HMA. This is achieved by keeping the paver at an even speed with the compaction operation. Fitts went over the best techniques for compaction. Some new mixtures/ technologies for thin HMA overlays are "smoothseal" and Novachip®.

***Scrub Seal & Fog Seals* - Steve Douglas, Ergon Asphalt / Western Emulsions, Inc.**

Douglas presented an overview of the materials, types, equipment, and construction guidelines for scrub seal and fog seals. Douglas defined a scrub seal as "a chip seal that utilizes an emulsion drag broom, used to rehabilitate roads with extensive cracking without having to apply crack seal prior to chip sealing." Fog seals are defined as "an application of diluted asphalt emulsion that protects and extends pavement life, lowers permeability, inhibits raveling, treats minor surface defects, coats and improves binder flexibility, enhances aggregate retention, and provides a uniform appearance." According to Douglas, fog seals are used because they are inexpensive, effective, efficient, and acceptable.

***Crack Sealing Techniques and Materials* - Vern Thompson, Crafco; Chandler, AZ**

Thompson stated that with pavement preservation, there is a right product for the right pavement at the right time, and that ultimately, the most important aspect of pavement preservation is safety. Crack treatments are useful because they prevent water intrusion into the sub-base, prevent incompressible, improve ride quality, and are cost effective. Crack treatments should be used when pavement failure is imminent and you wish to extend pavement life. Product selection should be based on your climate, whether you want short-term or long-term rehabilitation, and your budget conditions. Thompson strongly advises professionals not to paint the pavement with product when they are crack sealing because this product makes pavement slippery in wet weather conditions, causing accidents.

***Chip Seal / Best Practices* - Kevin King, TXI; Tyler, TX**

King presented on the best practices for chip seal application. According to King, seal coats rehabilitate cracks less than 1/4", raveling, bleeding, oxidized pavement, and lack of skid resistance. Seals coats do not strengthen existing pavement, increase load-bearing capacity, smooth out rough pavement, bridge major cracks, or eliminate the need for maintenance or reconstruction. Some factors affecting seal coat quality are the condition of the existing surface, design, equipment, materials, application technique, traffic volume, and weather.

Often, the pavement that is being sealed is too soft, and the newly applied aggregate, regardless of its size, will push into the pavement below. When this occurs, the new seal coat will become flush and will loose skid resistance rapidly. Pavement that is too dry and brittle will soak up the asphalt, prompting early rock loss or shelling. King went over the proper calibration methods for asphalt distributors and proper usage of application equipment. Aggregate selection should be based on the type of roadway, traffic volume and type, noise, aggregate availability, and freight consideration. After rolling, air voids should account for approximately 20% of the area. Aggregate particles should be 40-50% embedded on low volume roads and 30-40% embedded on high volume roads. Proper embedment depends on having good aggregate particle shape. King also went over the best practices for selecting the proper aggregate, aggregate application, spreading, rolling, and sweeping; and inverted prime seals.

### *TxDOT Questions/Discussions* - Joe Graff, TxDOT; Austin, TX

Graff presented on TxDOT's Preventive Maintenance Program. TxDOT's PM has a contract program for seal coat (chip seal), light overlays, and micro-surfacing, and it uses state forces and routine maintenance contracts for crack sealing, spot seals, and fog seals.

The goals of the Preventive Maintenance Program are to extend the life of pavement, improve safety, and reduce cracking and other failures. TxDOT is encouraging preventive maintenance, not simply corrective maintenance. TxDOT emphasizes industry professionals not to put down too much aggregate and to keep chip spreaders as close to the aggregate truck as possible. Graff encouraged the audience to review "Chip Seal Best Practices" by the National Cooperative Highway Research Program (NCHRP) as well as TxDOT's Seal Coat manual.

### *Hot-In-Place Recycling* - John Rathbun, Cutler Repaving; Lawrence, KS

Rathbun encourages people to evaluate their pavement to determine if it is a good candidate for recycling. There are three types of HIR: surface recycling, surface repaving, and remixing. HIR is a surface technique and cannot correct problems with the subgrade. HIR operates by preheating the existing surface, scarifying the surface, and then applying a recycling agent into loosened material.

At Cutler, machines are tied together electronically that can run continuously, so there are no bumps. Before choosing to recycle, some things to consider are the uniformity of the pavement, depth of the existing HMA, presence of chip seals, asphalt properties, bleeding, pavement distress, traffic level, and environment. Some potential benefits of hot-in-place recycling are the repair of distresses, extension of pavement life, completion of work within a single pass, and the improvement of ride quality, friction, appearance, and bonding.

### *Micro-Surfacing and Slurry Seals* - Barry Dunn, Viking Construction; Georgetown, TX

Dunn presented on the best practices for micro-surfacing and applying slurry seals. Dunn stated that 40% of a pavement's quality is lost in the first 75% of its pavement life, and after this point, its quality plummets dramatically. Therefore, Dunn stressed that preventive maintenance was crucial in pavement preservation within the first 3 years of a pavement's life before the pavement begins to show signs of failure. According to Dunn, preventive maintenance is far less expensive than corrective maintenance in the long run. Slurry seals may be used as a part of a preventive maintenance program, but Dunn warned that slurry seals will not stop reflective cracking. How much slurry costs and how long it will last depend directly on the condition of the existing pavement.

### *Pavement Management Systems* - David Peshkin, Applied Pavement Technology, Inc.; Downers Grove, IL

Peshkin presented on the software technology available for pavement management. Pavement management is the marriage of systems engineering and pavement engineering; it is a system in which optimum strategies are identified to maintain pavements at a desired level of serviceability. Information such as construction history, maintenance history, traffic volume, money availability, agency and user objectives, and future performance goals are inputted and stored in a database, where the information gets analyzed. The system provides a "feedback loop," which allows the system to learn from prior mistakes or successes. Information is collected through visual inspection, non-destructive testing, and destructive testing methods. After the data is analyzed, PMS software can offer a multi-year pavement rehabilitation plan, an impact analysis, and data for special studies. PMS is a fiscally responsible method to take care of pavements.

### *City of Los Angeles Pavement Preservation Program* - Bill Robertson, Director and Nazario Sauceda, Assistant Director; City of Los Angeles, Department of Public Works, Bureau of Street Services

Robertson and Sauceda provided a real-life example of how pavement management systems technology has worked to improve the quality of pavement preservation in the City of Los Angeles. Los Angeles has the largest street system in the United States, with 6,400 centerline miles and 28,000 lane miles, and up until the mid 1980s, all of its roads and alleys suffered 30 years of total neglect. Today, two-thirds of Los Angeles' street system needs immediate attention. Robertson and Sauceda have utilized PMS to gain the support of neighborhood councils around Los Angeles and increase their funding allocation to $80 million dollars, a figure that serves only to maintain rather than improve the city's pavements, but this is a figure that has increased over the years, largely due to the visual representation that PMS has offered to residents and politicians. An estimated $150 million is needed to actually improve Los Angeles' pavements.

## First National Conference on Roadway Pavement Preservation (October 31 - November 1, 2005)

Transportation Research Board (TRB), a division of the National Research Council that serves as an independent advisor to the federal government on scientific and technical questions of national importance, organized the First National Conference on Roadway Pavement Preservation in conjunction with joint sessions. The conference was held in Kansas City, Missouri on October 31-November 3, 2005.

Representing the Texas Pavement Preservation Center at the conference was Dr. Yetkin Yildirim, P.E. from the Center for Transportation Research. Also attending were Zane L. Webb, P.E., Director of the TxDOT Maintenance Division, and Joe Graff, P.E., deputy director for the TxDOT Maintenance Division. Dr. Yildirim submitted a paper, included in the conference proceedings: "Pavement Preservation Training in Texas." Using the current initiatives used by UT's Center for Transportation Research as his model, Dr. Yildirim described in his paper the available ways of disseminating information about preventive pavement maintenance, identified groups that should be targeted for training, and presented the viable and available training options.

The First National Conference on Roadway Pavement Preservation addressed all aspects of successfully implemented roadway pavement preservation activities, including management, engineering, economics, the establishment of strategic performance goals, and the implementation of routine maintenance, preventive maintenance, and minor rehabilitation activities. The contents of the conference were divided according to the network and project levels. The papers and presentations represented in those parts were on surfaced and unsurfaced roadway pavement program network and project treatment characteristics. All the papers from the conference were published together in the Transportation Research Circular in October 2005, issue number E-C078, and are also available as a downloadable PDF file at:

http://www.trb.org/conferences/preservation-asset/Program.zip.

The conference provided a great opportunity to share information, acquire new skills, and tap into the growing network of asset management professionals. In particular, it offered a unique opportunity for transportation professionals from areas in government, academia, and consulting to gain a more comprehensive understanding of roadway pavement preservation.

For more information on the conferences and future events visit these useful websites:

**Transportation Research Board (TRB):**
http://trb.org/

**First National Conference on Roadway Pavement Preservation:**
http://www.trb.org/conferences/preservation-asset/

**The National Academies:**
http://www.national-academies.org

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COLLEGE OF ENGINEERING TxDOT

# TEXAS PAVEMENT PRESERVATION CENTER Newsletter

ISSUE 2 / SPRING 2006

**Spring 2006 / Issue 2**

**Inside This Issue:**



## Our Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost.

## Contact Us


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## Issue Highlights

### TRB 85th Annual Meeting

The TRB 85th Annual Meeting attracted more than 9,500 transportation professionals from around the world to Washington, DC January 22-26, 2006. The meeting covered all transportation models, with approximately 2,600 papers and presentations in 500 sessions addressing topics of interest to attendees. Summaries of selected papers related to pavement preservation are included in this issue. The Transportation Research Board is a division of the National Research Council, which serves as an independent adviser to the federal government and others on scientific and technical questions of national importance. TRB's mission is to promote innovation and progress in transportation through research.

### 2006 Navigating Costs Symposium

The CTR Navigating Costs Symposium was held April 4 at The University of Texas at Austin with keynote speaker Dr. William Buechner, Vice President of Economics and Research for the American Road & Transportation Builders Association (ARTBA).

### 2006 TxAPA Seal Coat Conference

The Texas Asphalt Pavement Association (TxAPA) held their Seal Coat Conference on April 26-27, 2006 in Waco, Texas with approximately 300 attendees.

### Mark Your Calendar:
### 2006 Pavement Preservation Seminar

The Pavement Preservation Seminar will be held October 3, 2006 in Austin, Texas. Visit www.utexas.edu/research/tppc for continuing updates.

## *TRB 85th Annual Meeting Selected Pavement Preservation Papers*

**Cooling Rates in Hot-Poured Bituminous Sealants** by Peter Collins, J-F. Masson, and Imad L. al-Qadi

Collins et al. stated that the performance of bituminous sealants applied to cracks and joints is partly governed by installation. The rate of cooling after pouring hot sealants impacts rerouting traffic, adhesion of sealant / hot mix asphalt interface, and the sealant microstructure. To determine the extent of the rate of cooling, the change in temperature of three sealants was measured in field and lab tests. Tests showed that sealant bulk temperature was more than 50°C lower than the standard application temperature (180°C) almost immediately after pouring. The bulk temperature reached 40°C or lower within 15 minutes. These results indicated that traffic need only be rerouted for 15 minutes, as opposed to the common 30 minutes, because deformation is not a concern. While the cooling rate of bituminous hot poured sealants remained undetermined, it can be inferred that the time for a sealant to wet and bond to the HMA surface is extremely short. Thus sealant wetting propensity is crucial for a sealant to adhere strongly to pavement.

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**Probabilistic Life-Cycle Cost Optimization for Pavement Management at the Project-Level** by Dima Jawad and Kaan Ozbay

Jawad and Ozbay stated that optimizing the life-cycle cost of transportation infrastructure is a strategic approach for achieving sustainability of infrastructure systems. They present a life-cycle cost optimization model (LCCOM), developed for analysis at the project-level for pavement management. In order to identify a life-cycle strategy that can bring about an optimum gain to society, the life-cycle cost optimization must look at every feasible life-cycle strategy and consider every possible impact that may be caused by placing the system into operation. The research presented creates the opportunity for further exploration of project-level probabilistic cost optimization in real-world decision making. The main goal of life-cycle cost optimization is to ensure that infrastructure facilities are managed (planned, constructed, operated, maintained, and rehabilitated) in a manner that brings about the best gains to present and future generations. Life-cycle cost optimization is a broad concept that can be applied at different levels of evaluation and to different categories of infrastructure systems. A thorough research in this area has resulted in noticeable advancement as it is steadily being integrated into practice and the decision making process.

**Effects of Winter Weather and Maintenance Treatments on Highway Safety** by Liping Fu, Max S. Perchanok, Luis Fernando Miranda Moreno, and Quadar Ali Shah

Fu et al. attempted to quantify the effects of winter weather and maintenance treatments on the safety of highways. This research is integral for a cost-benefit analysis of alternative maintenance strategies and methods as well as effective communication of the impacts of these strategies and methods to the decision makers and public. Statistical analysis was performed on data collected from two highway routes in Ontario, Canada. The obtained data included daily accident occurrences, weather conditions, and winter maintenance operations. Researchers attempted to answer many questions in this comprehensive study, including 'How much improvement can be expected from technology-enhanced maintenance systems and operations?' The extent to which maintenance operations should be applied and the effects of application conditions were also studied. Anti-icing operations were confirmed to be more effective than the combined operations of plowing and pre-wet salting. Variation within these operations may be small despite the differences in weather conditions; therefore, crash frequency, as the object of study, becomes less quantifiable. Also, there is significant variation in local snow conditions due to drifting and shading, resulting in a large variation of snow cover and, therefore, safety. The project initiated the task of quantifying impacts of winter weather and maintenance operation on safety, but it has only focused on its effects on crash frequency. Future research should examine the impact of these factors on crash consequences. Past studies have found that the consequences of a crash are usually lower in winter seasons due to reduced travel speeds, but the effects of maintenance operations on crash frequency has yet to be quantified.

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**Optimum Dynamic Probabilistic Management Model for Long-Term Pavement Restoration Program** by Khaled A. Abeza and Maher M. Murad

Abeza and Murad presented sample results indicating the usefulness of the developed optimum dynamic probabilistic management model (ODPMM) in yielding potential long-term pavement restoration programs. Although future conditions cannot be estimated with certainty, this probabilistic model is a simple approach with minimal data requirements (initial state probabilities and transition probabilities). The derived state probability functions can then be used to develop a dynamic optimum decision policy for pavement system conditions. The optimum solution can be efficiently obtained using available linear programming software packages.

### Considerations for Establishing a Pavement Preservation Program by Teresa M. Adams and Myungook Kang

Adams and Kang established that a pavement preservation program cannot work effectively without a programmatic framework. Such an organization enables optimization and defensible pavement preservation decisions by providing the information needed to analyze and justify budget trade-off decisions. Adams and Kang discussed the essential characteristics of a pavement preservation program, obtained from the analysis of eight state transportation departments. The study noted that each dollar spent now on preventive maintenance saves up to six dollars in the future, and case studies show that pavement preservation programs can be established with relatively low investments and can lead to significant cost savings. Though agencies have been implementing pavement preservation techniques for a long time, agencies must create an organized program to realize the full benefits of such strategies. Ten features of a successful program were identified. For one, the motivation for establishing the program should be clear. Such motivations may include savings through pavement life extension, improved ride quality, and fewer rehabilitation projects. Also, preservation projects and strategies must be selected using consistent guidelines and databases. Agencies must also develop procedures for anticipating maintenance needs and provide a dedicated budget with federal support. Employees should be educated on benefits and concepts of pavement preservation, and ongoing program evaluations directly impact continued improvement and performance.

### Degradation of Bituminous Sealants Due to Extended Heating before Installation: A Case Study by J-F. Masson, Peter Collins, Sladana Bundalo-Pere, John R. Woods, and Imad L. al-Qadi

Masson et al. tested bituminous sealants that are applied to cracks and joints in pavements, bridges, and other civil engineering structures. The objective of their testing was to better understand the effects of installation on sealant properties. Crack sealing treatments are generally applied at 180°C, a temperature at which the sealant can degrade. By measuring the molecular size, type of bond (sealant to crack wall), and the temperature at which the sealing material becomes ash and gas, they found that the material was most degraded early in the morning as a result of long pre-installation heating times at 150°C. This non-oxidative degradation led to sealant stiffening, a result of changes in polymer structure and loss of bitumen and polymer contents. This loss of organic material resulted in an increase in filler content. Control of sealant preparation conditions prior to installation is crucial for optimized sealant performance. This control includes the time and temperature of the sealing material prior to and during installation.

### Infrastructure Asset Management Education: Active Learning and Engagement-Based Practices by Omar Smadi and Akili Waddah

Several transportation asset management courses are being taught as part of university curricula as the asset management of civil infrastructure facilities and systems becomes increasingly important. A few institutions have implemented well defined programs related to infrastructure asset management. Smadi and Waddah outlined a class offered at Iowa State University to civil engineering and transportation planning graduate students. Underlying the curriculum at Iowa State is the concept of ‘active learning’, broadly defined as any instructional method that engages students in the learning process. Cooperative and problem-based learning techniques are also used to enhance the role of group work and problem solving in engineering. Smadi and Waddah outlined the class syllabus, the active learning techniques utilized, and a sample class project. As asset management system development becomes more important, more demand will be placed on academic institutions to provide proper training. Thus efforts need to be made to standardize the training process, and education in this area can operate to further improve an engineer’s critical thinking and managerial skills.

### Risk Cost Model for Analysis of Performance Specified Pavement Maintenance Contracts by Ivan Damnjanovic and Zhanmin Zhang

Many transportation agencies are implementing outsourced performance-based pavement maintenance contracts that are intended to shift performance-related risks from public agencies to private contractors while allowing contractors greater flexibility in planning and executing maintenance activities. However, how to quantify the risk cost remains a concern, preventing some agencies from moving more aggressively toward the implementation of such contracts. Damnjanovic and Zhang presented a general and flexible framework for quantifying the risk cost of outsourced performance-based pavement maintenance contracts in order to provide transportation agencies with the information they need to make better cost-efficient decisions. The developed framework included the reliability-based pavement performance model, the preventive maintenance and rehabilitation models, and the risk cost model. The general methodological framework was illustrated with an example where the limit state function of the reliability model is formulated using the current AASHTO design methods for flexible pavements.

**Performance Evaluation of Bituminous Surface Treatment Using Third-Scale Model Mobile Loading Simulator** by Jusang Lee, Y. Richard Kim, and Emily O. McGraw

Lee et al. presented a new test protocol for performance evaluation of bituminous surface treatments (BST) based on the evaluation of aggregate retention, bleeding, skid resistance, aggregate embedment depth, cracking, and rutting. The third-scale Model Mobile Loading Simulator (MMLS3) examined the effects of mix parameters such as aggregate emulsion and application rates, fine content, and aggregate gradation on aggregate bleeding. Results indicate that the developed method supports the current BST design. Experimental work presented with the MMLS3 indicates that the amount of aggregate loss decreases as the application rate decreases, the emulsion application rate increases, the fine content decreases, and the gradation becomes more uniform. While the repeatability of this method requires more investigation, the MMLS3 method showed potential for evaluating the BST under realistic loading conditions.

**Optimum Decision Making and Uncertainty Analysis at Programming Level of Pavement Management Systems** by Ashim Shivakoti and Hamid R. Soleymani

Shivakoti and Soleymani based their study on the idea that decisions made at the programming level of Pavement Management Systems (PMS) have the highest economic impact and determine the effectiveness of decisions taken at the project selection and project levels. Pavement performance depends on many parameters, including construction quality, materials, environment, drainage, traffic, and the interaction of these parameters. Shivakoti and Soleymani presented a methodology to address the issue of optimum decision-making and uncertainty analysis. Goals of the proposed methodology included enabling the decision-maker to optimize budget allocation and providing the decision-maker with multiple optimal solutions in order to balance the objective function and the impact of uncertainty on the optimal solution.

***For more information on these or other TRB papers visit www.trb.org.***

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## Past Events

### Texas Asphalt Pavement Association Seal Coat Conference – April 26-27, 2006 – Waco, Texas

The Texas Asphalt Pavement Association (TxAPA) held their Seal Coat Conference on April 26-27, 2006 at the Waco Convention Center. The conference attracted approximately 300 attendees. The Association serves the needs of hot mix asphalt producers, contractors, liquid asphalt suppliers, and firms interested in improving and growing the hot mix asphalt industry. TxAPA consistently provides services and information to keep the industry on the competitive edge. A major goal of the organization is to provide training for design, testing, and management of hot mix asphalt materials.

***For more information visit www.txhotmix.org.***

### Center for Transportation Research "Navigating Costs" Symposium – April 4, 2006 – Austin, Texas

CTR hosted its annual symposium, "Navigating Costs," on April 4, 2006 at The University of Texas at Austin. CTR researchers addressed a variety of timely topics. Presentations were followed by a tour of the UT Microelectronics Lab. Keynote speaker Dr. William Buechner, Vice President of Economics and Research for the American Road & Transportation Builders Association (ARTBA) in Washington, D.C., discussed recent developments and the future outlook of highway construction costs. In addition to presentations, exhibitions of current research projects were displayed. The Texas Pavement Preservation Center (TPPC) gave a video presentation on the definition and economic benefits of pavement preservation as well as pavement preservation treatment types and procedures.

***For more information visit www.utexas.edu/research/ctr.***

## Upcoming Events

### Pavement Preservation Seminar
### October 3, 2006 – Austin, Texas

The Pavement Preservation Seminar, scheduled for October 3, 2006 in Austin, Texas, will present a thorough overview of the latest concepts, techniques, and materials related to pavement preservation. Seminar topics will include Asphalt Overlays, Scrub and Fog Seals, Crack Sealing Techniques and Materials, Chip Seal Best Practices, TxDOT Questions and Answers, Hot-in-Place Recycling, Micro-Surfacing and Slurry Seals, and Pavement Management Systems. In recognition of the need for education and training related to pavement preservation, AGC, AEMA, $FP^2$, and the Texas Pavement Preservation Center will collaborate in conducting the 2006 Pavement Preservation Seminar. The 2006 Seminar will be presented in conjunction with the 23rd Annual AGC of Texas Trade and Equipment Show.

***For updates visit the Texas Pavement Preservation Center (TPPC) website: www.utexas.edu/research/tppc.***

**Loop 360 in Austin, Texas**

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COLLEGE OF ENGINEERING
# TEXAS PAVEMENT PRESERVATION CENTER
# Newsletter
ISSUE 3 / SUMMER 2006

**Summer 2006 / Issue 3**

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### Our Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost.

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### Issue Highlights

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Visit www.utexas.edu/research/tppc for continuing updates.

**Seal Coat Aggregates** by Peyton Chatham, Vulcan Materials Company

Chatham presented on how midway shale lightweight aggregate and LRA are produced. At a sample quarry, three separate benches are mined; the top layer is overburden, which is dirt over shale. The shale is mined beneath the overburden, where lightweight aggregate is found. A typical mining bench is approximately 25-30 feet high, since Texas will not allow a rock face to be taller than 40'. Raw shale then gets broken down to 1.5" in a primary crusher. The crushed raw shale then goes through a secondary crusher, which has a 250' rotary kiln that heats the 1.5" raw shale feed up to 2000°F. The coal fired kiln in the secondary crusher expands and vitrifies the raw shale inside the rotary kiln, forming a ceramic lightweight clinker. The clinker then goes through a cooling process, after which it is conveyed into a screening tower, where it gets separated into different-sized aggregates. Conveyors deliver graded clinker to individually graded stockpiles. A calibrated underground conveyor system delivers a designated percentage of certain gradations to loadout. A final gradation is delivered into loadout, and a sample is taken to verify unit weight and proper gradation. At this time the material can be loaded directly into the delivery vehicle (if it is uncoated) or stockpiled for verification testing or to be precoated. A pugmill is used for precoating (CSS-1H emulsion is used with AC-20 as the base). Precoating is monitored by automated metering devices and weigh-in motion scales.

The first stage of the LRA process is similar to that of shale. LRA is produced via conventional mining methods, which are used to produce a blend of lean and rich rock for performance and TxDOT specifications. Rich rock, which is a limestone rock with asphalt actually embedded within the rock, and white rock, which is a limestone without embedded asphalt, are blended together to meet state specifications for the LRA precoat. A primary crusher, typically a gyratory or jaw crusher, breaks down the rock into 3x5" size. The crushed rock then travels to a secondary crusher, where it gets broken down into smaller sizes and pit fines get removed. Crushed rock then goes through a third crushing process and is screened for sizing to produce LRA. Single-sized aggregate gets placed into stockpiles. Stockpiled material then gets re-screened, blended, and mixed with Flux Oil. This process is operated by an automated control center located in the mixing plant. Pre-mix and precoat is produced simultaneously.

Chatham then presented the classification criteria for the Tex-499-A Aggregate Quality Monitoring Program (AQMP). Criteria I is Class A rock, a low carbonate source with 70% or greater acid insoluble residue and 25% or less magnesium sulfate soundness. Criteria II is Class B, C or D rock that must have Magnesium Sulfate soundness and polish value. Class A and B are normally required for surface treatment. Class A may be blended with HMA only and is not permitted to be blended with seal coat aggregate. In 2003, Texas had a total of 115 local sources for sandstone, limestone/dolomite, gravel, igneous rock, and synthetic aggregate. An aggregate's mineral type will determine its resistance to polishing, affinity to asphalt, and skid resistance. Particle size will affect the asphalt content and lift thickness. Particle shape will affect the asphalt content, skid resistance, and resistance to degradation. Cleanliness will affect the adhesion between asphalt and aggregate and durability, and toughness will affect resistance to degradation and weathering. Texas specifications require uniform-size aggregates; angular (crushed) particles at a minimum of 85% with two or more crushed faces, cubical shape, and minimal flat/elongated particles for better skid resistance; and a cleanliness rating of 2% maximum soft particles/ deleterious material. New specifications (Tex-406-A) require a 1/5% maximum decant. Also, toughness and soundness of aggregate in Texas must have an LA Abrasion below 35% loss and 5-cycle $MgSO_4$ soundness of less than 25% loss. LA Abrasion stands for the "Los Angeles Abrasion Test" (AASHTO T96, ASTM C131), which represents the resistance of coarse aggregate to abrasion, where the aggregate is subjected to damage from rolling with steel balls in a drum (value is expressed as percentage loss). For example, extremely hard igneous rock has approximately 10% loss, and soft limestone and sandstone has approximately 60% loss. The Magnesium Sulfate Soundness test estimates resistance to weathering, simulates freezing and thawing action, and results in a total percentage loss.

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**Chip Seal Asphalt Providers** by Chuck Dannheim, Sem Materials

Dannheim gave a thorough presentation on asphalt chip seal binders, beginning with a presentation on the origin of asphalt. All sorts of petroleum products come out of an oil well. Oil product goes through a refinery and then a distillation process. Light-end product is typically gasoline, heavier products may include kerosene and diesel, and the heaviest "bottom of the barrel" product is asphalt. There are three types of asphalt chip seal binders: hot asphalt cement (AC) applied at +/-350°F, cut-back that is diluted with a solvent like fuel oil or diesel at +/- 250°F and emulsified applied at +/-160°F. AC is a hot-applied asphalt binder that is generally graded according to viscosity and typically modified with polymer or tire rubber to improve quality. To be kept in suspension, an asphalt emulsion is basically an asphalt molecule that is surrounded by soap (emulsifier or surfactant), which in turn, is surrounded by water. Because they are suspended, asphalt emulsion can be used without the aid of heat or solvents and can be pumped, stored, and applied at much cooler temperatures than other asphalt. An emulsifying agent (surfactant) such as soap is soluble in water and oil.

Emulsifiers have a surface charge; the hydrophilic head is typically either positive or negative, and like charges of the emulsifier repel one another, keeping the asphalt droplets in suspension. An emulsion is made by introducing molten asphalt and treated water under pressure into a colloid mill, which is a high-shear mixing device specially designed for this purpose. The colloid mill divides the asphalt into very small droplets of about 0.001 to 0.005 inches, and the type of asphalt and emulsifying agent used is specific to the grade of emulsion being produced. Emulsion must be stored at between 50°F and 185°F, depending on the intended use and specific product. It must not be heated above 185°F nor allowed to freeze. The temperature of the heating surface must not exceed 212°F, nor can forced air be used to agitate the emulsion. When heating the emulsion, agitate it gently and not too often to eliminate or reduce skin formation. If possible, use warm water for diluting, and add water to the emulsion (not emulsion to the water). Avoid repeated pumping and recirculation, and pump from the bottom of the tank. What is often observed in the industry is the overheating of emulsion and burning off the water right around the heating unit, which causes the material to break inside the tank. Many times, a skin cap will form at the top of the tank, and that is why it is important to pump from the bottom, and if using the same tank repeatedly for the same product, it is best to never allow the tank to get completely empty so that the top layer skin cap never gets penetrated. It is important to always remember that anionic (negative-charged) and cationic (positive-charged) emulsions repel each other and do not mix (example: SS-1H and CRS-2H will not mix); mixing the two will create a very expensive mess. Also, do not mix different classes, types, and grades of emulsified asphalt, and do not dilute rapid setting emulsions. Medium and slow setting grades may be diluted, but water must be added very slowly.

One of the simplest tests is the viscosity test, which determines how thin or thick a material is. (It needs to be thin enough to spray through a distributor but thick enough to stay on a road surface.) TxDOT specifications (TxDOT T 202) require an absolute viscosity of 140°F and 275°F, which is typically the AC product. The TxDOT T 59 test determines the demulsibility of a seal coat emulsion to test how quickly a seal coat emulsion will break. Demulsibility is highly variable and may be affected by ambient temperature. The penetration test is conducted at 77°F with a sharp-pointed pin penetrated into asphalt for five seconds. Ductility is tested at 39.2°F to determine how much asphalt will stretch. The ductility test basically determines how much resistance an asphalt can withstand and still hold onto the rock. The elastic recovery test determines how asphalt is able to pull back into place. Fast-driving cars will pull rock out of the asphalt; it is important for asphalt to be able to pull the rock back into place. The softening point test determines the temperatures asphalt can withstand since Texas roadways commonly have 120°F to 130°F surface temperatures.

The qualities needed in a chip seal binder are even distribution without streaks or flowing. It must be able to retain aggregate the first day, the first winter, and beyond. It should serve as a long-term sealing for a roadway surface while being cost-effective. Lab tests are designed to determine how products perform in the real world, and help to promote quality.


**Fog Seals** by Steve Douglas, Ergon Western Emulsions, Inc.

Douglas presented fog seals as a viable, cost-effective option to extend pavement life a few years. Fog seals are an application of diluted asphalt emulsion that protect and extend pavement life by lowering its permeability, inhibiting raveling, treating minor surface defects, coating and improving binder flexibility, enhancing aggregate retention, and providing a uniform surface appearance. Fog seals are primarily used on roads that been applied with a chip seal or seal coat, HMA, or microsurfacing or slurry seal. The materials used in fog seals are slow- or medium-setting emulsions diluted with water to produce a low viscosity that will not "break" before penetrating pavement voids. (The more penetration that is allowed by an emulsion into deeper voids, the better it will enforce a pavement.) Standard emulsions are cationic CSS-1 or CSS-1H or an anionic SS-1, SS-1H, or MS-2 (though MS is slowly being replaced by better products). For these materials, a polymer is usually not needed. Another fog seal material that is widely used is a rejuvenating emulsion such as the cationic CMS-1P. The rejuvenating emulsion is modified with a polymer, making it more expensive than a CSS-1; therefore, the polymer-modified emulsion should only be used in areas where it is absolutely needed (primarily older, more aged roadways). The emulsion will be diluted with water; potable water is suitable most of the time but the PH must be within an acceptable range (city water may sometimes fall slightly out of range). The water must be free from any detectable solids or incompatible salts (treated water should be fine). Dilution rates should be either 50/50 water to emulsion or 60/40 water to emulsion. Rates beyond these are generally not acceptable. Equipment for making fog seals include a broom or sweeper to brush off dust, a distributor with a proper sized nozzle to shoot lower rates with a good fan, a traffic control crew, and a sand truck as a precautionary measure.

If a roadway is prone to shelling and existing damage is relatively minor, then fog seals with a CSS or SS binder are a good, inexpensive option for enhancing aggregate retention and preserving pavement life for a few years. When extending the life of an older seal coat road, it is a good and inexpensive practice to fog seal to extend its life a couple years before paying more money for an asphalt seal coat. With fog seals, hot-applied and emulsion asphalt binders are the same once they have cooled down and water has drained away. Aggregate will have an impact on a fog seal because it will either be pre-coat or bare, natural or manufactured, and will be of varying size gradation and air voids. Proper application rates will depend on the size of air voids, size of aggregate, and porosity. A Grade 5 aggregate is typically shot at 0.08-.10 gals/yd$^2$, Grade 4 at 0.10-0.12 gals/yd$^2$, and Grade 3 at 0.12-0.14 gals/yd$^2$. It may be cost-efficient to fog seal atop a micro/slurry seal to extend pavement life for a few years since costs for microsurfacing are also increasing. Before placing a fog seal atop a micro/slurry seal, let the roadway age for at least 3 years and use an application rate of 0.08-0.10 gals/yd$^2$. Finally, when using a 60/40 emulsion shoot a little more material than when using a 50/50.

When is it appropriate to fog seal HMA? The answer depends on many different variables. HMA materials include asphalt binder (modified or unmodified), aggregate (natural or manufactured), and modifiers such as tire rubber and ash. HMA is either semi-permeable or permeable. Semi-permeable types include dense-graded mixes and stone matrix asphalt (SMA), and on these, application rates should be 0.06-0.10 gals/yd$^2$. Permeable HMA includes OGFC and PEM, and these need an application rate of 0.10> gals/yd$^2$. Dense graded mixes are of fine or coarse grades, well-graded aggregate asphalt binder with or without modifiers, and of a mix design such as Hveem, Marshall, or Superpave. SMA materials include a gap-graded aggregate and modified asphalt binder. Mix designs for SMA include Superpave and Marshall. Open-graded mixes are more conducive to fog seals. Materials for open-graded mixes include aggregate (crushed stone with manufactured sands) and modified asphalt binder. The mix design for open-graded mixes is NCAT 99-3. HMA mixes, including Superpave, tend to age faster, at variable rates between 1-5 years. Applying a fog seal atop OGFC or Porous European Mix (PEM) seems contrary to their design, which is intended to be open graded. However, air voids in open graded courses eventually become clogged. Placing just enough material to produce minimal clogging on a worn-out HMA roadway is an effective means to keeping a pavement in good condition. It is important to keep in mind that fog sealing an HMA will reduce its skid resistance. Construction guidelines for fog sealing require a distributor in good working order with a proper shooting rate, proper dilution rate and shooting temperature, clean and dry pavement, acceptable weather conditions, and optimum application rate (avoiding too little or too much material).

A fog seal is not as effective as a seal coat because it is diluted and applies less material, but it is a cost-effective means to efficiently extend a pavement's life for 1-3 years.

**Seal Coats for Pavement Preservation** by Tom O'Leary, Ergon Asphalt & Emulsion

O'Leary gave a thorough overview of seal coat best practices. A seal coat is generally a single, double, or triple application of asphalt material covered with aggregate. Surface treatments are applied to prepared base courses or other surfaces. Seal coats are applied to existing pavements to extend the life of the pavements, but they are not intended as permanent pavement surfaces and have a life expectancy of approximately five years. The service life of a seal coat varies depending on situational conditions such as traffic volume and weather. Seal coats correct deficiencies such as cracks, raveling (or shelling), bleeding, aged or oxidized pavement, low skid resistance and also provide the appearance of a uniform surface. Seal coats, however, will not strengthen existing pavement, increase load-bearing capacity, smooth out rough pavement, bridge major cracks wider than 1/8" (cracks wider than this size must be crack sealed in advance), or eliminate the need for maintenance or reconstruction. Within the first three-quarters of the life cycle of a pavement, there is a 40% reduction in quality, but in the following 12% of the life cycle, the quality of the pavement plummets into total failure. Thus a seal coat should be applied during this initial three-quarter period. Some factors affecting seal coat quality are existing pavement surface condition, the experienced capability of workers applying the seal coat, equipment, materials, application technique, traffic, and weather. A raveled surface will require more binder; a slick surface will require a lighter binder. Bleeding pavements requires a lighter application rate.

Seal coating is an art, not a science, and seal coat design is simply a starting point: be prepared to deviate from the design. It is necessary to have a good eye once you get out onto the road to see exactly what is going on. The contractor superintendent, engineer designer, inspectors, operators, suppliers and taxpayers all play a role. Inspectors need to be adequately trained and need to have the freedom to make timely and informed field decisions. They need to develop partnering relationships with the contractor and suppliers and understand that plans are only a guide and that each road requires special considerations.

Suppliers are excellent resources for information on their respective products.

Before applying a seal coat, an old roadway should be patched, crack sealed, and thoroughly cleaned. Likewise, unpaved surfaces need to be primed unless inverted prime techniques are being used. Keep in mind that hot or cold mix patches need adequate curing time. If this is not possible, then a fog seal should be considered instead of a chip seal. Herbicide should be applied to surrounding vegetation, and gutter areas and curbs should be vacuumed, particularly in urban environments.

To prepare for seal coating, it is necessary to calibrate equipment, know proper design rates, understand factors affecting rate adjustments, determine rock lands, strap the distributor for accurate readings, and ensure that proper signing and traffic control are in place. Calibrate the distributor's spray bar height, nozzle angle, spray bar pressure, and computer or asphalt meter. A double coverage spray bar is most commonly used; a triple coverage spray bar is not recommended because it is susceptible to wind, which will affect binder consistency. Computer-controlled aggregate spreaders need to be calibrated for proper rate distribution, and the gates and hitch need to operate properly. The shot should be set to the size of the aggregate rather than the size of the distributor so that binder gets covered in a timely fashion. Stockpiles should be placed in strategic locations for better production.

It is extremely important that trained operators drive the aggregate spreader at a controlled ground speed to reduce skids and prevent rock from turning over. It cannot be overemphasized that the aggregate spreader should never move faster than the distributor. The spreader box should be directly behind the distributor (the quicker the aggregate gets applied, the better the bond will be). On high heat afternoons, however, the spreader box should back off slightly.

Trucks should be of adequate size and quantity. Measure and record the volume within each truck. Control the trucks' speed throughout the project. Stagger the dump trucks in and out of the wheel paths or station them down the roadway. Check tires periodically for proper inflation and cleanliness.

Rollers should be pneumatic only (three medium or four light pneumatic rollers are recommended), and tires should be clean and properly inflated. Rolling must take place immediately after the spreading of aggregate. The slower the roller moves the better, and rollers should always be moving because if it is sitting, it will squeeze aggregate down and push binder up. When a job is delayed for more than 10 minutes, rollers and trucks should be moved off of the fresh seal.

For traffic control, flagmen, signs, and a pilot car are needed. The flagging stations should be constantly moved, and the pilot car should maintain slow speeds. Traffic control should also clean up messes; clean-up must be done immediately because on a hot day, a mess will get tracked through a whole job.

The proper aggregate for seal coating should be clean, single-sized, and cubical for optimum performance; avoid flat particle shapes and uncrushed gravel since these do not offer skid resistance. Do not use pre-coated aggregate with emulsion binder because it has a tendency to dramatically slow the break of the emulsion and will stay tender for a very long time. Pre-coated aggregates should only be used with hot AC binders. The cost of single-sized aggregate deters their usage in most states, but a method to determine the number of "flatter" particles should be used when using graded aggregates. Aggregate with minimal fines should be used since fines will settle at the bottom if there are too many in the mix, preventing the proper embedment of larger aggregate into the binder and resulting in the loss of cover stone and bleeding. Natural and synthetic aggregate can be used. Aggregate selection depends on the type of roadway, volume of traffic, existing weather conditions, availability of aggregate, and cost.

Voids are the spaces between the aggregate particles; as aggregate particles are dropped into wet asphalt settling should occur in disoriented positions. After rolling and traffic, aggregate will be seated in their flattest position. Voids should account for 20-30% of the area before rolling and should account for roughly 20% of the area after rolling. For good performance, voids should not be filled completely with asphalt binder. On low volume roads, voids should generally be 40-50% full. On higher volume roads, voids should be only 30-40% full. Hot AC is typically applied at 320-350°F. Hot AC loses 150-200°F in the first 30-45 sec. after application, so it is imperative to apply aggregate on AC while it is still very hot. The more fluid the binder is, the better it will adhere to the aggregate. Application of aggregate should be one rock thick, and if aggregate is applied correctly, there should be little or no remaining excess to sweep after a job.

To avoid excess joints, asphalt should be applied to the entire area of intersections and widenings first before applying aggregate. Paper the joints at all starting and stopping points, and shoot on clean surfaces only. Use 1/2 nozzles or end nozzles on longitudinal joints. Nozzles should never be squared because doing so will actually produce a double shot; two nozzles are needed for a proper shot.

Marginal surface temperature requires excellent construction techniques. Do not shoot too late in the day if working under questionable weather conditions; there needs to be plenty of time for proper curing before nightfall, since it is typically the wet or cold nighttime conditions that will ruin a seal coat.

Operators are often under pressure to get a job done and may be inclined to rush. Under these conditions, when tracking occurs, the first instinct is to raise the aggregate rate. This is the wrong thing to do. In reality, trimming the rock rate will stop the tracking. Aggregate rate is extremely important and affects more than just the look of the road. Too much aggregate will cause binder to push up.

In a high traffic situation, skid marks occur where trucks have to stop for traffic. An innovative way to solve this problem is to break up the application. Shoot three miles, and then skip a shot for the next 3,000 feet. This way, traffic always starts and stops on the old surface. At the end of the day, fill in the parts that were skipped. By doing this, skid marks can be avoided and patching will be unnecessary. In a day, one transport load of production may be lost, but no patching will be required.

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### **Seal Coat Preparation** by Bennie McCormack

McCormack gave an overview of some important aspects of seal coat preparation. McCormack emphasized that the cause of failure should be repaired prior to the application of a seal coat. If the cause of failure is not addressed, then it will always reemerge. Prior to applying a seal coat, all failures should be repaired, ruts should be filled, cracks should be sealed, edges should be sprayed with herbicide, high edges should be cut off, and public access intersections should be repaired. Repairs should be completed a minimum of three months (preferably six months) in advance of seal coat application, and fresh patches and edges should be fog sealed. If a roadway has a lot of problems, a full depth repair should be considered. When crack sealing, pour all cracks to prevent water form entering the base and sub-grade, which would cause more problems. This type of repair should be completed in the fall prior to applying the seal coat. This will allow adequate curing time and reduce bleeding. Hot or cold pour materials may be used. When using hot pour, six months is needed for curing, with cold pour materials, seal coat application can take place on the following day. On high traffic areas, hot pour material may come back up through the seal coat, and under heavy truck traffic can actually entire sections of pavement may actually be pulled up. Edge cracking in Texas increased after the drought last summer; these cracks must be crack sealed too. Excess crack seal material around the crack should be removed in order to prevent bleeding. Fresh patches can be fog sealed to prevent loss of rock and bleeding. Herbicide likewise prevents growing vegetation from breaking up and separating pavement. Pavement edges should then be fog sealed. All broken edges should be repaired to prevent edge drop off and to maintain the width of roadway. Another good practice is to edge seal or fog seal in the fall season before the seal coat application. Cut off all build-up on the edges to get water off the road rather than down the edge. Getting the water off of the road and not standing on it will help prevent damage. Public access intersections such as rest and picnic areas should be kept in as good repair as major roadways.

Asphalt repairs under three months old should not be sealed. Edge seals should not be applied after a seal coat. Leveling-up should not take place after a seal coat application. Do not seal dirty gutters. Do not wait until it is too late to get begin preparatory work. Do not use tack for blade lay patches. Completing all repairs at least three months prior to seal coat application will increase the odds of a successful seal coat. With all phases of preparatory repair work complete and the selection of appropriate aggregate and asphalt application rates, a roadway can last 5-7 years.

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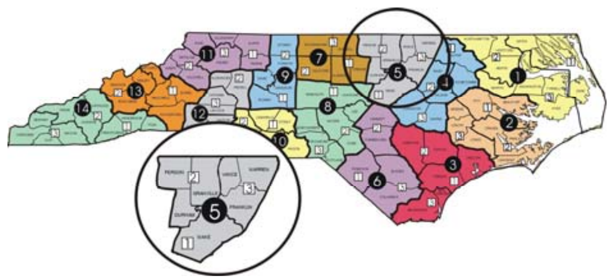

### **Building North Carolina's Pavement Preservation Program** by Emily McGraw, P.E., NCDOT

NCDOT has offices in one-hundred counties in North Carolina with central offices in Raleigh, North Carolina. There are 14 divisions in NC, which are comparable to the 25 districts in Texas. Each division has its own organizational engineering structure. They have division engineers down to the county maintenance engineers, and the real work happens at the county level in the local field offices. There are 78,615 total miles of roadway in NC, with 14,705 primary miles; 63,910 secondary miles; 58,117 paved miles, and 5,793 unpaved miles. North Carolina is second in the nation to total miles, behind Texas. NCDOT maintains county road systems as well from subdivision roads to interstate highway. Preservation in NC is a cost effective approach.

The NC pavement preservation program involves retreatment (generally in the form of surface treatments), resurfacing with 1-1.5 inches of plant mix, and rehabilitation, where more work is required. Retreatment keeps pavement that is structurally adequate but is declining with some oxidation and insignificant cracking in good condition. Retreatment involves chip seals/seal coat (a mat and seal, which is a larger stone aggregate of a #67 stone; straight seal, which is a single application; split, which is two applications of aggregate; and a triple seal, which is three applications of aggregate with a #78 stone or a 5/16" lightweight aggregate). NCDOT also does contract work with slurry seals and microsurfacing. Resurfacing is a single application of plant mix asphalt to an existing roadway. NC uses Superpave on all roadways for resurfacing (using new mixes, S4.75A and SF9.5A, which allow lying down less than a 1.5").

Rehabilitation is used when pavement is failing and when traffic volumes, particularly trucks, make the current pavement layers inadequate for future use. In NC, whenever a rehab job is considered, an engineering investigation is undertaken first. Coring and DCPs are taken to learn the thickness and condition of existing pavement. The FWD is used to determine the strength of existing pavement. Detailed pavement condition notes are taken to locate areas that are requiring more work. Traffic volume is taken into account.

In implementing the pavement preservation program in NC, training is key. The program began in 2000 when NCDOT started offering the first two National Highway Institute (NHI) pavement preservation courses, targeting field personnel, county maintenance engineers, division engineers, and division administration. It is necessary to obtain support from field personnel, who are the people making decisions on which roads to treat (decisions are at the local level not central). Preservation strategy is a better strategy than "worst first," which is hard to sell because people call most frequently about roads that are in bad condition. So, a lot of effort has been spent on convincing citizens of the preservation strategy. NCDOT implemented a Maintenance Management System (MMS) and soon a new Pavement Management System (PMS) from the same supplier will be implemented in order to keep better track of total costs.

NCDOT is also doing research in area of maintenance. They use new products all the time and are investigating fabrics beneath overlays, fog seals, rejuvenating agents, and new crack filling material. Currently they are taking data from their surface treatment database and doing modeling to see how much they can realistically expect from seal coats. NCDOT has funded three research projects with NC State ($250,000); they are taking a look at aggregate gradations, the rolling and compacting of chip seals, and are doing a life cycle cost analysis that compares traditional CRS-2 emulsion with a polymer-modified emulsion. Research is crucial because it is a financial investment to determine what really works, and it saves money in the long run.

NC has dedicated funding initiatives. Senate Bill 1005, landmark legislation for NC, allowed the use of Trust Fund cash balances over a 3-year period, targeting NC and U.S. routes. NC spent $423 million as an investment to bring up the roadway system to standard, which included substantial work like milling and HMA overlays. In 3 years, 1500 miles were treated. The focus has been on preserving the primary highway system. A second initiative called North Carolina Moving Ahead is an economic stimulus package, which is using $630 million to focus on a backlog of resurfacing needs. Safety, the reduction of traffic congestion, and the development of a PP program are components. This initiative focuses on the secondary roadway system. The challenge is how to secure recurring funding (so far NCDOT has been successful in getting non-recurring funding). Year 2004 produced the most robust budget ever in NC. NCDOT spent $28 million on a chip seal program for 2,800 miles (45.64% of the roadways). The last legislative initiative is the Road Oil Incentive Program, which means to increase productivity and efficiency. It is one of two pilot programs that tests incentive pay for employees as a means of increasing efficiency and productivity Incentive award for employees was 0.25% of the budget allocation and was increased to 0.50% for 2006. Incentive payments are based on the exceeding of previous years' production rates (measured in square yards per man-hour), the maintenance of a good safety record, and no disciplinary action. In order to not sacrifice quality for quantity there is an oversight committee. Divisions perform quality control audits; the central office monitors bi-weekly production rates, and field audits and reporting audits are performed.

Every two years, NCDOT conducts a pavement condition survey. Currently, roads chosen for treatment are in better condition than they were four years ago. The benefits of PP program have been a higher rate of productivity, more efficient operations, more miles paved, lower unit costs, the promotion of employee initiative, the encouragement of creative thinking, the improvement of roadway conditions, and a best practices management.

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### **The Prime Coat** by David Stroud

Stroud gave an overview of the prime coat. A prime coat is designed to bond to the top course of a base, strengthening the top 1-2 inches of base. It protects the base prior to application of a surface treatment, creates a workable platform, and serves as a means for dust control.

There are different prime coat types: spray prime (ex: MC-30, AE-P); worked-in (cut-in) prime; and covered (inverted) prime. Types of base material used for prime coat are limestone, caliche, iron ore gravel, gravel, fly ash stabilized base, cement treated base, and asphalt stabilized base. Limestone and caliche are the most widely used. Cement treated limestone base is hard to get 3/8" penetration, so frequently, the base will sanded once a prime coat has been shot on it. A pneumatic roller should be used first when preparing to treat the base. Seventeen districts use pneumatic rollers whereas 20 districts use steel wheel (others use combination). Districts also have different prime coat methods: seventeen use a MC-30 Spray, nine use AE-P, six use RC-250 Covered Prime, six use a MS-2 or MS-1 Cut-in, four use a SS-1 or CSS-1H Cut-in, and one district uses Dirty Water (refers to a spray of a very light shot of emulsion). Optimum conditions for a base for prime coat application is a "no-dust" base, a reasonably smooth finished base, a reasonably porous finished base, a strong base, and appropriate moisture condition in the base. Keep in mind that prime sometimes does not cure out very well in the shade of a tree.

If too much prime is shot a little stickiness on top will result, and it will track. In response to the question of whether or not an AE-P should be shot straight or diluted on a limestone base, districts answered that it depends: if a distributor gives streaks, it is better to dilute the AE-P for better distribution. It is also worth noting that sprayed-on diluted MS-2 prime on a limestone base does not penetrate quite very well. Traffic will wear off the prime coat off its base. If traffic is allowed to run on top of a prime coat the next day, the rock will typically eat the prime up. So, it is necessary to pay attention to equipment on the road.

Stroud also addressed why surface treatments should be applied in cool weather at all. There are multiple reasons cool weather seals are done. Districts who do them are weighing the risk versus the reward. Various products are available for cool weather application, but none are perfect for every situation. The following products are considered cool weather specific products: AC12-5TR, CRS-1P, and MC-2400. The rejuvenating product CMS-1P is not cool weather specific but it serves well, especially in late spring. Fourteen districts in Texas use CRS-1P, six use AC-5, three use AC-12 5TR, two use AC 10+Ltx, two use AC 5+Ltx, two use CRS-2P, two use MC-2400, and two use MC-3000.

To increase the chances for success, it is extremely important to pay attention to the weather forecast. It is the cold or wet night-time temperatures that typically ruin a job. It may be necessary to start late in the day and stop early. Late spring is a dangerous time for cool weather products that contain dilutants. A fog seal can be cheap insurance when doing this. Applying a fog seal is highly recommended if traffic will be occurring on a wintertime seal. Potential problems with cool weather application include weather issues such as extreme cold or rain. In such conditions, traffic may have to be held off longer. Cool weather products can contain solvents and are softer asphalts so hot weather is an issue also (for example, late spring). Pre-coated aggregate with emulsions can be done but the process is slow and there must be no traffic for hours.

***Watch video of the TxAPA Seal Coat Conference proceedings at www.utexas.edu/research/tppc/conf/txapa/.***

**Upcoming Events**

**Pavement Preservation Seminar**
**October 2-3, 2006 – Austin, Texas**

The Pavement Preservation Seminar, scheduled for October 2-3, 2006 in Austin, Texas, will present a thorough overview of the latest concepts, techniques, and materials related to pavement preservation. Seminar topics will include Asphalt Overlays, Scrub and Fog Seals, Crack Sealing Techniques and Materials, Chip Seal Best Practices, TxDOT Questions and Answers, Hot-in-Place Recycling, Micro-Surfacing and Slurry Seals, and Pavement Management Systems.

In recognition of the need for education and training related to pavement preservation, AGC, AEMA, $FP^2$, and the Texas Pavement Preservation Center will collaborate in conducting the 2006 Pavement Preservation Seminar. The 2006 Seminar will be presented in conjunction with the 23rd Annual AGC of Texas Trade and Equipment Show.

***For updates visit the Texas Pavement Preservation Center (TPPC) website: www.utexas.edu/research/tppc.***

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COLLEGE OF ENGINEERING

TxDOT

# TEXAS PAVEMENT PRESERVATION CENTER Newsletter

ISSUE 4 / FALL 2006

**Issue 4 / Fall 2006**

**Inside This Issue:**




## Issue Highlights

### ICAP Québec 2006

Sponsored by the International Society for Asphalt Pavements (ISAP), the 10th International Conference on Asphalt Pavement was held August 12-17, 2006 in Québec City, Canada. Over 600 people from around the world attended ICAP, which included a pre-conference program with courses and workshops, a technical program with over 180 paper presentations and an separate exhibition of consultants, manufacturers, suppliers, technical associations, and government agencies in the field of asphalt pavements. Dr. Yetkin Yildirim represented the Texas Pavement Preservation Center at ICAP 2006, presenting a paper entitled "Pavement Preservation Training." Enclosed in this newsletter are highlights of ICAP papers that focus specifically on pavement preservation.

### Mark Your Calendar: 2006 Pavement Preservation Seminar

The Pavement Preservation Seminar will be held October 2-3, 2006 at the Austin Convention Center in Austin, Texas in conjunction with the 23rd Annual Association of General Contractors of Texas Trade & Equipment Show. Sponsors for the Seminar are the Asphalt Emulsion Manufacturers Association (AEMA), Associated General Contractors of Texas (AGC), Foundation for Pavement Preservation ($FP^2$), Texas Pavement Preservation Center (TPPC), and UT Center for Lifelong Engineering Education. Online registration begins September 2006. Please visit www.utexas.edu/research/tppc for more details.

***ICAP Québec 2006***
***Selected Pavement Preservation Papers***

**Advances in Hot In-Place Recycling Technology** by John Emery

Hot in-place recycling (HIR) of functionally deteriorated but still structurally sound asphalt pavements is a cost-competitive alternative process of potentially equivalent quality and performance with less road-user disruption, compared to hot-mix asphalt (HMA) overlay and milling/ HMA filling processes. The Martec AR2000 third generation HIR process is based on recirculating forced hot-air with low-level radiant heating, processing (hot milling), post heating, drying, mixing, paving, and a compaction system. This AR2000 third generation HIR system effectively deals with the recycling depth, heater efficiency and effectiveness, speed and productivity, emissions, and processing uniformity problems associated with previous second generation HIR systems. Preheaters heat and soften deteriorated old asphalt concrete using a combined hot-air/ low-level radiant heating system. Air in the combustion chamber is heated to about 600˚C and blown on the pavement through holes in the manifold, with the spent hot air recuperated and reheated. The softened old asphalt concrete is not damaged, and emission levels are very low. The preheater/ hot miller applies additional heat to enable the hot milling heads to loosen and remove softened asphalt pavement without degrading old asphalt mix. This unit has automatic depth control, and the hot milling heads can be adjusted to widths of 3.2-4.0 meters. The postheater/ dryer-mixer uniformly heats and dries while thoroughly mixing old, loosened asphalt mix with added new, corrective aggregate or HMA. The old, recycled asphalt mix is transferred to a pugmill for final mixing. The fully mixed renewed HMA is then transferred to a conventional paver for laydown, followed by compaction. When recycling to a depth of 50 mm, the AR2000 work speed may vary from 2-6 m/min, with an average production rate up to 10,000 $m^2$ of HIR typically completed per 10 hour working shift. Monitoring of AR2000 HIR projects, particularly Ontario Highway 401, has shown good performance, better than second generation HIR, micro-surfacing and milling/ filling with new or recycled HMA. The AR2000 third generation HIR process has demonstrated the ability to consistently and cost effectively renew and enhance premium asphalt surface course mixes. With the use of more long-life asphalt pavements and the recognition of top-down cracking surface distress, HIR should have an increasing role in asphalt pavement renewal. This will also involve associated asphalt technology advances such as Superpave, polymer modification, rejuvenator characterization and selection, and performance evaluation of the mix, in an overall systems approach to optimized HIR.

**Analysis of Road Maintenance Sequences According to the Evolution of Distresses** by F. Brillet, T. Lorino, and T. Dumeix

Within the framework of preventive maintenance policy by the French national network, pavements are subject to systematic distress monitoring programs and condition indicator measurements: sideways force coefficient, transverse unevenness and macrotexture. This methodology was established in 1992 as the “Quality Image of the National Roads” (IQRN) and includes a triennial survey of different distresses with a calculation of the total index. The analysis of such data made it possible to define laws of evolution for distresses, depending on initial structures, traffic and successive maintenance operations. In order to complement this approach, a joint analysis of the pavement evolutions and maintenance sequences was undertaken. Presented are statistical analyses of the relation between the evolution of observed distresses and maintenance decisions. Also presented is the pavement lifespan prior to overlay, according to observed deterioration, and the chosen maintenance technique to combat deterioration. The selection considers asphalt pavements excluding cement stabilized bases. The study shows that there are implicit rules, more or less marked, concerning the priority given to maintenance and the choice of the technique used (surface dressings, thin or thick asphalt overlays), according to the encountered problems (skid resistance, plastic deformation, fatigue or thermal cracking). The French road network comprises about a million km. of roadways. Thermal cracking and skid resistance are generally the pathologies that trigger maintenance. Of course, fatigue problems deserve more investigation. In order of magnitude, fatigue, which accounts for 20.7% of all pathologies on French roadways, corresponds to structural works (19.4%), while bearing capacity and plastic deformation (10.8%) correspond to heavy structural works (9.3%). All this reveals that, overall, the national network pavement structures were correctly designed, either at construction or after strengthening. The wearing courses found on French roads are primarily asphalt concretes (AC) and surface dressings (SD). The formula of ACs depends on their thickness, which is declined from "ultra-thin" to "semi-coarse”. Two questions were asked: “Which are the pathologies appearing on a given type of surface?” and “Which type of maintenance does a given pathology trigger?” In answer to the first question, there did not appear to be a clear relation: the surfacing does not seem to influence the observed pathology. Differences are related more to traffic level. Only some simple analyses were presented here, with, as principal conclusions, an evaluation of the past policies and practices followed by the decision makers. We could see, as well, that the roads with strong traffic had resistant pavement structures, which explain the prevalence of the maintenance works answering surface pathologies (skid resistance or thermal cracking), whereas the roads with low traffic, of which the pavement structures are often old and some never really strengthened, would more often require heavy works, which are not carried out in all cases.

**APT as a Tool for the Development of Design and Performance Models** by A. A. A. Molenaar

Molenaar summarized the work conducted at Delft University in close cooperation with the Dutch Ministry of Transport in the field of Accelerated Pavement Testing (APT). In the Netherlands, the APT device LINTRACK has been used for: verification of thickness design and pavement evaluation methods, development of visual condition performance models, permanent deformation behavior of several asphalt concrete mixtures and structures, calibration of design models for wearing courses on orthotropic steel bridge decks and response and performance studies on innovative pavement structures. APT has been used to determine to what extent linear elasticity can be used to predict strains and displacements in asphalt pavements. It has also tested if a mechanistic pavement design method based on linear elasticity could provide an accurate and acceptable estimate on the structural lifetime of asphalt pavements. During performance tests, regular measurements were made of the longitudinal and transversal strains at the bottom of the asphalt layer due to the test load, and also regular measurements were made of the permanent deformation and extent of cracking. Furthermore, FWD measurements were regularly performed. In conclusion, linear elasticity can be used and acceptable accurate pavement life predictions can be made provided that ample attention is placed on the characterization of traffic and climatic influences as well as material characterization.

**Asphalt Pavement Rehabilitation: Using Sustainability in Decision-Making** by M. Maher, K. Clarke-Whistler, and L. Uzarowski

Road networks, whether they are in the developed world or in the developing world, are a cornerstone of economic development. As the world population continues to increase and the earth's ability to sustain this growth is decreasing, the principles of sustainability must be incorporated into all aspects of the planning, design, construction, rehabilitation and maintenance of road networks. The impact of development on world ecosystems is a function of growth in population, increasing affluence (such as measured by income per capita) and technology (as measured by emissions per unit of production). Population growth and increasing affluence are realities; thus, the levers available to us to help slow the continual depletion of limited resources must focus on improvements in technology. Over the past 25 years, applied pavement research has given pavement design engineers tools to incorporate greater innovation into pavement rehabilitation schemes. One resource management tool that can assist highway agencies, planners, contractors and design engineers in identifying mechanisms whereby social, financial and environmental issues can be integrated into the management and planning of road rehabilitation works is a simple rational process for incorporating the principles of sustainability in a meaningful way into selecting the optimum road rehabilitation design. Any system that assesses contributions to sustainability must consider economic, environmental and social impacts. The economic and environmental aspects can be relatively easily quantified, but social opportunities are generally less tangible and so more difficult to integrate in a practicable tool. To allow some quantification of the sustainability of a particular pavement rehabilitation option, a simple selection tool has been developed based on an approach put forward for the management of construction and demolition waste in land development projects. In this suggested sustainability selection process, a series of indicators are applied to the specific road project. The output is in the form of a total score for each performance indicator comparing the viable rehabilitation alternatives. This then allows the stakeholder acceptability of each sustainable criterion to be compared, and the use of weighting factors allows each alternative to be scored from a sustainability perspective.

**Automated Paving with Data from Road Surface Profiling** by P. Ekdahl, B. Nielsen, and B. Sävinger

The result from pavement maintenance often displays a difference between what is planned and the actual result on the road. Differences occur regarding asphalt volume or thickness, cross fall, and longitudinal evenness. The final result is mainly dependent on three factors: existing road surface profile, chosen maintenance technique (often asphalt thickness), and the actual work performance. In order to reduce these differences, a new methodology of how to perform and implement geometrical overlay designs has been developed. The methodology involves a geometric overlay design based on road surface profiling over the whole road width with Laser RST for an optimal balance between fill and mill volumes. The design is transferred to a digital guidance file for the paving machine. The innovation consists of a description of suitable combinations of hard- and software and a methodology for how to perform the paving works and a modified method to analyze the measured longitudinal profile. Furthermore, the system works with a relative length measurement, without any other local reference systems. This enables a simple and cost effective positioning system. The whole procedure has been tested on several projects. It has been especially actualized in connection to the current traffic safety program in Sweden, where many roads are re-designed to a 2+1 lane solution with rails separating the traffic. Those designs often require a transfer of the height ridge, a road widening and a corresponding change in geometry. The procedure has been awarded a prize for "Innovation of the year 2004" by the Development Fund of the Swedish Construction Industry.

**Chip Sealing Systems: Improving Early Age Chip Retention** by Anton Kucharek, Keith Davidson, and Jean-Martin Croteau

A number of solutions aiming at better chip retention have been tried over the years, such as using quick-set polymer-modified emulsions, using smaller and cleaner chips or modifying certain aspects of construction practices. This paper is intended to take an in-depth and more systematic look at various technical aspects that can have an impact on improving early chip retention by an asphalt emulsion. A group of asphalt emulsions were selected for this laboratory study, containing both anionic and cationic types and having different types of polymer modifications. Curing of the emulsions was studied by assessing the development of film strength in the binder layer by rheological measurements and by the Frosted Marble Cohesion test. Subsequently, chip retention on a variety of stone types was assessed by means of the Sweep Test for Surface Treatments. Ten asphalt emulsions were analyzed with respect to their curing properties during the first 24 hours. Each emulsion was subsequently tested with three different aggregates for assessing stone retention using the sweep test. The cationic emulsions studied developed cohesion and modulus quicker than the anionic emulsions under similar curing conditions. The distillation residues showed comparable modulus values, but the time needed for the curing emulsions to achieve that modulus range was significantly shorter for the cationics. Measuring the cohesion of the curing emulsion by the Frosted Marble test reflected the same trend. The type of polymer modification of the emulsion impacts the film strength development in the very early stages of curing. PMA emulsions can benefit of their polymer content within the first 2 hours while emulsions containing latex require more curing time before the polymer becomes of benefit. Within 24 hours under the described curing conditions, their performance becomes comparable. This behavior has been more obvious with cationic emulsions. Anionic emulsions containing PMA and latex have shown fairly similar behavior. Combination PMA-Latex emulsions have performed well, but no special benefit has been observed so far from having the SBR polymer both inside and around the asphalt binder. More research is needed to fully characterize such systems. The strain tolerance of the emulsion residues increases with curing. As they cured faster, the cationic emulsions in our study have shown less strain dependency during early stages. This should be beneficial for improved early stone retention, as failure in fresh chip seals is predominantly cohesive in nature. The study allowed no direct comparison between distillation residues and cured emulsions, as during the first 24 hours at room temperature complete curing of the emulsions is not achieved. However, the properties of distillation residues seemed to poorly reflect the properties of cured cationic latex modified emulsion residues in particular, confirming earlier literature observations. The cationic emulsions have performed consistently better in sweep tests with all the aggregate studied. They have also shown less sensitivity towards the different chemical composition of the stone than the anionic emulsions. The results of research underlined the many factors that affect early stone retention following the construction of a chip seal. It emphasized the need for the engineer to thoroughly assess all the aspects affecting the final chip seal design. Good material evaluation, selection and understanding beyond basic specifications are critical of achieving best possible results.

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**Compaction of HMA with a Vibratory Pneumatic Tire Roller** by Y. Nose Y. and J. Scherocman

A new method to compact Hot Mix Asphalt (HMA) pavement was recently developed in Japan. This system consisted of a relatively small, seven tire pneumatic tire roller that can be operated in the vibratory mode–a vibratory pneumatic tire (VPT) roller. It was previously found that the VPT roller could achieve the required level of density in a HMA mix using fewer roller passes and that the roller achieved a more uniform degree of density throughout the thickness of the HMA pavement layer. In 2005, three additional test sections were constructed to further evaluate the capabilities of the VPT roller. The first project was at the Bakersfield Airport in California, where the density achieved with the VPT roller was compared with the density obtained with a static pneumatic tire roller that weighed more than twice as much. The second trial was conducted in Georgia, where various roller combinations were tested. It was determined that both the mainline pavement density and the longitudinal joint density were easily achieved when the VPT was included in the roller train. The third project was located in Japan, where it was confirmed that the use of the VPT roller would provide for a uniform density distribution throughout the depth of the pavement layer. The combination of the kneading action of the pneumatic tires and the vibratory force applied through the pneumatic tires provides “the best of both worlds” regarding the compaction of HMA mixtures.

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**Design and Instrumentation Plan for a Long Life Pavement in Ontario** by B. Lane, T. Kazmierowski, S. Chan, and Dr. J. Ponniah

One of the primary priorities for transportation agencies is the extension of pavement service life and the reduction of delays to the public. Perpetual pavements or long life pavements are one answer to these demands. These pavements increase the time between resurfacing, with a corresponding rise in structural value. A perpetual pavement is essentially a flexible pavement that is designed to resist structural failure, minimize cracking and rutting, and last for more than 50 years with only occasional maintenance. The Ministry of Transportation in Ontario, Canada (MTO) will begin construction of its first perpetual pavements this year in 2006, beginning with Hwy 406 and a reconstruction of Hwy 402. The reconstruction project will be conducted in three different sections: a 4 km section of perpetual pavement with a rich bottom mix as a lower binder; a 4 km section of perpetual pavement with Superpave 25 mm as the lower binder and a control section of conventional flexible pavement. Installed moisture probes, earth pressure cells and asphalt strain gauges will collect data from these sections to help understand how different pavement structures react and perform under various traffic and climatic conditions. Data results will greatly assist in assessing the field response of perpetual or long life pavement designs, particularly in regard to design criteria and methodology, failure mechanisms of the different pavements, how asphalt material properties relate to long life behavior, the optimum maintenance strategy for perpetual pavements, how to calculate the life cycle costs and benefits, impact of material and construction and the adoption of perpetual pavement concepts.

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**Development of Hot In-Place Transforming of Dense Graded Asphalt Mixture to Porous Asphalt Concrete** by H. Hosokawa, A. Gomi, T. Okuno, F. Goto, S. Tanaka, and A. Kasahara

A new technology has developed for hot in-place that is different than hot in-place recycling. Called Hot In-Place Transforming, the new technology transforms dense graded asphalt concrete to two layers of porous asphalt as the surface layer and mastic gap asphalt that supports the layer. The process consists of a train of 5 automated machines, 2 preheaters, a heater/miller, a separator and a mixer/tandem-paver followed by conventional rollers. The key to the new technology is the separator with a screening device that separates hot asphalt coated aggregates according to size. To produce even heating for efficient aggregate separation, hot air is used as an air mat rather than jet air, which is what hot in-place recycling machinery uses. The tandem paving technology paves through one pass for two layers of different-graded asphalt mixes. The new technology was tested successfully in 2005 on Route 77 in Okinawa, Japan, demonstrating that the operation ran at a speed of 2m/min and paved porous asphalt with a single pass. Water permeability and surface roughness requirements were satisfied. It is also notable that a large reduction in greenhouse gas emission, including that of carbon dioxide, was achieved through this new rehabilitation process as compared with the conventional mill/fill process.

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**Evaluation of Automated Distress Collection Techniques: An Ontario Case Study** by R. Capuruco, S. Tighe, L. Ningyuan, and T. Kazmierowski

Pavement management systems (PMS) rely on consistent and repeatable distress data collection to perform efficiently. This data has been traditionally collected via manual surveys, which tend to be subjective and time consuming. The Ministry of Ontario (MTO) has initiated a study with the University of Waterloo to determine if certain systems may be suitable for collecting data at a high rate of speed and with state-of-the-art image capture equipment and ultimately, for replacing the traditional manual approach. MTO will be producing a set of recommendations and guidelines. In so doing, a data management plan for collecting consistent data was set in place, and a set of similar distresses were selected to serve as the response variables. An advanced analysis of variance was then conducted to permit statistical data comparisons among contractors and the automated technologies. Results indicate that there are not significant differences between contractors' measurements using the sensor-based equipment, but significant differences in measurement were observed with measurements taken using digital image-based technology. Improvements could be made in the quality of the image-capturing, providing more training to data analysts (process related problem), or enhancing/ proof-checking distress identification-oriented algorithm's routines (software related problem). Additionally, this might provide an opportunity for agencies to introduce new and/ or stronger standardization practices for image-based technique. Furthermore, in order to better assess the new technology's accuracy, it is necessary to compare its data results with that of manually-acquired data results.

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**Evaluation of Cold-in-Place Recycling Using Foamed Asphalt** by A. Loizos, V. Papavasiliou, and C. Plati

Cold In-Place Recycling (CIPR) using foamed asphalt stabilization is a viable alternative for rehabilitating pavements in comparison to the increasingly expensive process of hot in-place recycling.

In light of the increasing cost of hot mixed asphalt mixtures and the limited availability of good materials, Cold In-Place Recycling (CIPR) using foamed asphalt stabilization offers an attractive alternative for rehabilitating pavements. Because of its limited performance history and the unavailability of a standard mix design procedure, the use of CIPR using foamed asphalt stabilization had been limited mainly to low to medium volume roads. The lack of experience, at least as far as the performance of the aforementioned technique for heavy duty pavements is concerned, was the reason for the Greek Ministry of Public works to undertake a field experiment on the purpose of the rehabilitation of a severely damaged heavy trafficked highway (part of the Trans European Network) that incorporated semi-rigid and flexible pavements. In order to achieve this goal, a comprehensive monitoring and data analysis research study was performed, concentrating on the Falling Weight Deflectometer (FWD) as a major tool for the in situ evaluation of the early life performance of the recycled pavement. In addition, roughness as well as Ground Penetrating Radar (GPR) measurements, accomplished with in situ material coring and related laboratory tests, were performed. The major findings of the research study are presented and discussed in the present work.

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**F. E. Study of Critical Cracking Condition in Asphalt Overlay** by F. Moghadasnejad and S. Toolabi

It is readily observed that HMA overlays may prematurely display cracking patterns similar to those that were existent in the old, underlaying pavement. Such cracking is due to the inability of the overlay to withstand the shear and tensile stresses created by movements concentrated around preexisting cracks. Moghadasnejad and Toolai studied the main factors in the development of cracks in overlays using the finite element method. Factors that were investigated included crack width, overlay thickness, and load position. Evaluation criteria included tensile stresses, shear stresses, and the stress intensity factor. According to results, it was concluded that, by themselves, any of the single fracturing modes (opening or shearing, for example) were not enough to calculate asphalt overlay fatigue in comparison to a combination of fracturing modes. It is shown that existence crack at the bottom of overlay causes increasing shearing stresses up to five times in comparison to overlay without any cracking. According to results, an increase in tensile and shear stresses near the crack tip are in some extent related to crack width.

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**Good News on Quality of Automatic Crack Collection** by P. Offrell, Juha Äijö

Since the 1980's automatic road surface measurements of rutting and unevenness has been performed on the Finnish road network using automated level of service measurement vehicles. Crack data has been collected manually by visual inspection, and the Finnish Road Administration (Finnra) has an ambition to replace the crack inventory methodology with automatic crack measurements. This paper describes a test project conducted June 2004, where automatic crack data collection was made with two different types of crack measurement equipment, — PAVUE and Adhara system (previously known as "Samsung system ") — and visually. The scope was to investigate the benefits and drawbacks of automatic crack data collection and estimate which measures should be used to present the automatically collected crack data on network and project level. The conditions for the test were normal production type measurements and the length of the test sites were 100 km. The results show that both automatic crack data collection equipment could produce crack data with good quality. The repeatability varies with used equipment type. The sensitivity was influenced by the used illumination while collecting the crack data and the pavement type (Asphalt Concrete or Soft Asphalt). The test showed that existing automatic methods can replace manual surveys on road network level with both improved quality and more detailed information of, for example, the crack position, etc. Based on the results from the test project, the Finnish Road Administration has decided to start using automatic crack data collection from the year 2006.

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**Improvement of the Surface Characteristics Regarding the Safety and Comfort of the Users** by Yves Brosseaud and Michele St-Jacques

The main concerns of the construction financing authorities and people in charge of road maintenance in industrialized countries concentrate on the improvement of safety of the users and on the comfort of road displacements, and also take into account bordering populations. A judicious choice of the structures (durability) and especially of the nature of the wearing course, makes it possible to offer a combination of better conditions of adherence while authorizing a significant reduction of the noise level and a better division of the space for the various road users. A database on the skid resistance performances (CARAT) allows the consolidation of the state of knowledge on the performance of pavement surfacing and contributes to developing and evaluating new products. The influence and the durability on skid resistance of a particular family, including the composition, grain size, nature of the binder and polishing strength of the aggregate, is examined. Use of a highly skid-resistant surfacing on more hazardous sites, coupled with application of the micro-encrustation technique designed to enhance early-age skid resistance, is also detailed herein. Current trends with respect to road maintenance and surfacing choices are indicated. The article closes with a look at the prospects for new techniques to enable increasing the durability of surface characteristics and thus spacing the schedule of maintenance interventions.

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**Innovative Surfacings: What's New in New Zealand?** by Bryan Pidwerbesky and David Faulkner

Jawad and Ozbay stated that optimizing the life-cycle cost of transportation infrastructure is a strategic approach for achieving sustainability of infrastructure systems. They present a life-cycle cost optimization model (LCCOM), developed for analysis at the project-level for pavement management. In order to identify a life-cycle strategy that can bring about an optimum gain to society, the life-cycle cost optimization must look at every feasible life-cycle strategy and consider every possible impact that may be caused by placing the system into operation. The research presented creates the opportunity for further exploration of project-level probabilistic cost optimization in real-world decision making. The main goal of life-cycle cost optimization is to ensure that infrastructure facilities are managed (planned, constructed, operated, maintained, and rehabilitated) in a manner that brings about the best gains for present and future generations. Life-cycle cost optimization is a broad concept that can be applied at different levels of evaluation and to different categories of infrastructure systems. A thorough research in this area has resulted in noticeable advancement as it is steadily being integrated into practice and the decision making process.

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**Modeling Long-Term Flexible Pavement Performance of Ontario Highways** by N. Li, T. Kazmierowski, and B. Lane

The Ministry of Transportation of Ontario (MTO) uses several multiple performance indices in the newly implemented MTO Second Generation Pavement Management System (PMS/2). These indices can be used jointly or individually to assess pavement performance in terms of overall Pavement Condition Index (PCI), ride comfort index (RCI), International Roughness Index (IRI), and Distress Manifestation Index (DMI). Each of the evaluation indices may be used to address current pavement serviceability and predict future trends in functional adequacy, such as pavement structural strength and distresses. This study presents the long-term flexible pavement performance observed in the field after reconstruction or rehabilitation, as represented by a number of pavement maintenance and rehabilitation (M&R) strategies that are commonly used for preservation of the Ontario highway network. Historical construction records and provincial contract documents indicate that all of the

1,732 pavement sections in the provincial network have experienced at least one if not several significant rehabilitation activities since 1985. The long-term pavement performance trends of these pavement sections have been reported annually by PCI, RCI and DMI for the past twenty years. The paper concludes with discussions and recommendations to modify the existing pavement performance prediction models that are currently used in the PMS/2 through correlation with the actually observed pavement performance trends for each type of pavement rehabilitation/reconstruction treatment.

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**Optimization of Joint and Crack Sealant Selection Criteria Based on Laboratory and Field Performance** by T. Worms, A. Shalaby, and L. Kavanagh

The optimized selection of joint sealants can extend pavement service life and reduce annual maintenance and rehabilitation needs, particularly in regions, which experience extreme climatic conditions. Early sealant materials were not subjected to standardized testing procedures, and many failed as a result. Since then, several empirical test procedures have been proposed, and a few have been adopted into approved standards by bodies such as the American Society for Testing and Materials (ASTM). Variability within the sealants, their application methods, and the empirical nature of the test methods made it difficult to predict sealant behavior in the field. The purpose of this research was to develop a performance-based laboratory testing approach, and to investigate and rank the performance of eight types of hot-pour joint and crack sealants for applicability of use in Manitoba. The research is a joint effort between the Manitoba Department of Transportation and the University of Manitoba. The project involved laboratory testing of sealants to verify fundamental properties and performance simulation under cyclic loading at three test temperatures: +30ºC, 0ºC and -30ºC. The results of the laboratory tests indicated that ASTM Type I (high modulus) sealants exhibited higher initial resistance to loading and also experienced adhesion failure at both the 0ºC and -30ºC test temperatures. The ASTM Type IV (low modulus) sealants generally exhibited lower resistance to load, and three of the eight sealants did not show signs of failure at any of the three test temperatures. In an effort to optimize the sealant selection criteria, the laboratory performance is compared with field performance in a controlled field trial. The trial involved evaluation of the failure rates of sealants on an asphalt pavement section on the TransCanada highway, which is the primary highway that connects Canadian provinces.

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**Overlay Tester: A Simple and Rapid Screening Test for Characterizing Crack Resistance of HMA Mixes** by Fujie Zhou and Tom Scullion

Stiffer binders and good stone-to-stone contact may provide improved rut resistance, but they may also reduce the mix flexibility and thus, crack resistance. Today this cracking phenomenon is getting more attentions from pavement engineers. Cracks appear in flexible pavements primarily through fatigue, low-temperature, or reflective cracking mechanisms. This paper investigates the feasibility of using the Overlay Tester (OT) as a simple test for characterizing crack resistance of asphalt mixes. The OT can be run on standard size samples, typically 150 mm long by 75 mm wide by 38 mm high, which can be prepared from either field cores or from lab molded specimens. Sensitivity studies indicated that the OT provides reasonable results, in that raising the asphalt performance grade and decreasing the testing temperature will lead to shorter cracking life. Furthermore, in a series of controlled tests it was found that asphalt absorption by aggregate appears to have a major impact on crack resistance of asphalt mixes. The effectiveness of the OT as a crack resistance test was validated by five reflective cracking case studies in Texas and test conducted on cores from MnROAD low-temperature cracking sections. The OT results correlated well with field performance. A laboratory study was also conducted to compare the OT results with those from the bending beam fatigue tests. A good correlation was also obtained. In summary, the OT device appears to be a practical tool to characterize cracking resistance of asphalt mixes and to let the mix designer balance the competing requirements of both rut and crack resistance.

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**Pavement Preventive Maintenance Concepts and Techniques** by D. Hein and J. M. Croteau

Many pavement owner/agencies are now focusing on maintaining the overall value of their roadway assets and are striving to make better-informed decisions on how they allocate funding to minimize the deterioration of their assets. This new form of management, referred to as Asset Management, has clearly identified the benefits of strong pavement preventive maintenance programs compared to the commonly used “worst-first” repair approach. A strong pavement preventive maintenance program offers an opportunity to help close the gap between pavement maintenance needs and optimal pavement condition to better serve the traveling public. An effective pavement preventive maintenance program encompasses a full range of techniques with the goal of enhancing pavement performance in a cost-effective and efficient manner. A framework of mix-of-fix strategies, which includes a balance between pavement preventive maintenance work along with pavement rehabilitation and reconstruction, can assist a road agency to maintain an overall acceptable pavement condition, while meeting the needs of the traveling public. This concept, as simple as it seems, has not been fully accepted by roadway agencies, who continue to react to problems after they occur rather than preventing them from occurring in the first place. This paper describes the concepts of pavement preservation and outlines several typically pavement preservation techniques.

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**Practical Aspects of Maintaining a Busy Old Motorway, While Keeping Traffic Moving** by P. L. Scott and K. van Donderen

The M4 motorway, close to London Heathrow Airport, Windsor and Slough, needed maintenance. This major maintenance scheme, which cost £13million; involved a three-lane dual carriageway 4 kilometers long. No major work had been carried out on it since 1970, and it carries 160,000 vehicles per day into and out of London, with the main flows between 6am and 10.00pm. There were substandard features that included discontinuous hard shoulders, which meant that hard shoulders could not be used for traffic management to keep traffic flowing. Little or no work could be carried out during the day without causing enormous congestion as it is very close to the M25, the main London orbital motorway. The road runs through high-density residential areas, which made noisy nighttime working an issue. All this makes this road to be almost unmaintainable. A contract duration of 20 weeks was set as the maximum that road users, businesses and residents could tolerate. As a consequence, the design was changed and re-scoped to achieve a pavement design life of some 10 years before the next major maintenance whilst keeping the traffic moving in the meantime. This included a very large free vehicle recovery operation. A comprehensive communications strategy was also developed for the scheme, which commenced nine months in advance of works starting on site. This communication strategy and plan made a significant contribution to the whole scheme being a success. Traffic delays were almost held to the norm. This paper discusses how the works were tailored to suit the constraints, the comprehensive approach to informing the Road Users, Stakeholders, Press and residents, and how current practices within the Highways Agency have changed.

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**Recent Development in Recycling Binders for In-Place Cold Recycling of Bituminous Aggregate** by J. M. Croteau and K. Davidson

Many millions of square metres of roadway have been rehabilitated using the in-place cold recycling process in Canada. The driving engine of in-place cold recycling is associated with the concept that existing pavements are sources of primary roadway materials. The existing pavement is reclaimed and transformed into a bituminous aggregate, treated with a recycling system and placed and compacted in-place. The nature of recycled mixtures differs significantly from hot mixtures. Hot mixtures are usually two-part systems, whereas, recycled mixes are multi-part systems, including: aggregate, aged binder, recycling binder and possibly corrective aggregate and other additives. Additionally, water is added during recycling for coating and compaction. The air voids content of recycled mixtures is much greater than hot mixes. A small amount of recycling binder is added to bituminous aggregate; consequently, the build up of cohesion of recycled mixtures is highly dependent on the nature of recycling binder, the properties of aged binder, the addition of corrective aggregate and additives, if required, the curing conditions and the mixture densification. The selection of recycling system is based on the characteristics of bituminous aggregate, the expected interaction of recycling binder with aged bitumen and the site constrains/conditions. The paper proposes a classification of recycling techniques based on objectives, materials and recycling systems. It defines the performance of recycled work in accordance with material mechanistic properties and field constructability. It provides information on the parameters used to engineer recycled mixtures. Finally, it describes the field conditions that influence the performance of recycling material.

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**Return on Investment Analysis for Long Life Asphalt Pavements** by R. Haas, S. Tighe, and L. Cowe Falls

It is becoming increasingly necessary in life cycle analysis (LCA) of infrastructure assets, including pavements, to take a longer term approach than in past, conventional practice. This is largely for reasons of ensuring sustainability and assessing the future impacts of today's decisions. Life cycle analysis can be primarily in terms of life cycle cost analysis (LCCA) but can also include considerations of resource conservation, environmental impacts, energy balance, etc. A reasonable time horizon for life cycle analysis should involve short, medium and long term periods, in the order of 25, 50 and 100 years, respectively. Conventional LCCA compares competing alternative investment strategies and can involve a range of stakeholders, from the elected level to the public at large to suppliers and consultants. Of the methods available, present worth of costs is almost exclusively used in the pavement field. However, when medium to longer term life cycle periods are involved, rate-of-return and cost-effectiveness formulations can be applicable and should be considered. A numerical example is provided which shows how an agency can determine the internal rate of return (IRR) for an investment alternative involving a long life different pavement design and a life cycle period of 50 years. Conventional LCCA for calculating present worth of costs will undoubtedly continue to be used in the pavement field as a primary tool. However, going beyond conventional LCCA and using a rate-of-return or cost-effectiveness formulation, especially for medium to longer term life cycle periods, should be given more consideration.

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**Surface Treatments in Asphalt Pavements: A Systems View** by S. Senadheera

Fu et al. attempted to quantify the effects of winter weather and maintenance treatments on the safety of highways. This research is integral for a cost-benefit analysis of alternative maintenance strategies and methods as well as effective communication of the impacts of these strategies and methods to the decision makers and public. Statistical analysis was performed on data collected from two highway routes in Ontario, Canada. The obtained data included daily accident occurrences, weather conditions, and winter maintenance operations. Researchers attempted to answer many questions in this comprehensive study, including 'How much improvement can be expected from technology-enhanced maintenance systems and operations?' The extent to which maintenance operations should be applied and the effects of application conditions were also studied. Anti-icing operations were confirmed to be more effective than the combined operations of plowing and pre-wet salting. Variation within these operations may be small despite the differences in weather conditions; therefore, crash frequency, as the object of study, becomes less quantifiable. Also, there is significant variation in local snow conditions due to drifting and shading, resulting in a large variation of snow cover and, therefore, safety. The project initiated the task of quantifying impacts of winter weather and maintenance operation on safety, but it has only focused on its effects on crash frequency. Future research should examine the impact of these factors on crash consequences. Past studies have found that the consequences of a crash are usually lower in winter seasons due to reduced travel speeds, but the effects of maintenance operations on crash frequency has yet to be quantified.

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**Considerations for Establishing a Pavement Preservation Program** by Teresa M. Adams and Myungook Kang

Adams and Kang established that a pavement preservation program cannot work effectively without a programmatic framework. Such an organization enables optimization and defensible pavement preservation decisions by providing the information needed to analyze and justify budget trade-off decisions. Adams and Kang discussed the essential characteristics of a pavement preservation program, obtained from the analysis of eight state transportation departments. The study noted that each dollar spent now on preventive maintenance saves up to six dollars in the future, and case studies show that pavement preservation programs can be established with relatively low investments and can lead to significant cost savings. Though agencies have been implementing pavement preservation techniques for a long time, agencies must create an organized program to realize the full benefits of such strategies. Ten features of a successful program were identified. For one, the motivation for establishing the program should be clear. Such motivations may include savings through pavement life extension, improved ride quality and fewer rehabilitation projects. Also, preservation projects and strategies must be selected using consistent guidelines and databases. Agencies must also develop procedures for anticipating maintenance needs and provide a dedicated budget with federal support. Employees should be educated on benefits and concepts of pavement preservation, and ongoing program evaluations directly impact continued improvement and performance.

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**Degradation of Bituminous Sealants Due to Extended Heating before Installation: A Case Study** by J-F. Masson, Peter Collins, Sladana Bundalo-Pere, John R. Woods, and Imad L. al-Qadi

Masson et al. tested bituminous sealants that are applied to cracks and joints in pavements, bridges, and other civil engineering structures. The objective of their testing was to better understand the effects of installation on sealant properties. Crack sealing treatments are generally applied at 180°C, a temperature at which the sealant can degrade. By measuring the molecular size, type of bond (sealant to crack wall), and the temperature at which the sealing material becomes ash and gas, they found that the material was most degraded early in the morning as a result of long pre-installation heating times at 150°C. This non-oxidative degradation led to sealant stiffening, a result of changes in polymer structure and loss of bitumen and polymer contents. This loss of organic material resulted in an increase in filler content. Control of sealant preparation conditions prior to installation is crucial for optimized sealant performance. This control includes the time and temperature of the sealing material prior to and during installation.

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**Infrastructure Asset Management Education: Active Learning and Engagement-Based Practices** by Omar Smadi and Akili Waddah

Several transportation asset management courses are being taught as part of university curricula as the asset management of civil infrastructure facilities and systems becomes increasingly important. A few institutions have implemented well defined programs related to infrastructure asset management. Smadi and Waddah outlined a class offered at Iowa State University to civil engineering and transportation planning graduate students. Underlying the curriculum at Iowa State is the concept of ‘active learning’, broadly defined as any instructional method that engages students in the learning process. Cooperative and problem-based learning techniques are also used to enhance the role of group work and problem solving in engineering. Smadi and Waddah outlined the class syllabus, the active learning techniques utilized and a sample class project. As asset management system development becomes more important, more demand will be placed on academic institutions to provide proper training. Thus efforts need to be made to standardize the training process, and education in this area can operate to further improve an engineer’s critical thinking and managerial skills.

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**Optimum Decision Making and Uncertainty Analysis at Programming Level of Pavement Management Systems** by Ashim Shivakoti and Hamid R. Soleymani

Shivakoti and Soleymani based their study on the idea that decisions made at the programming level of Pavement Management Systems (PMS) have the highest economic impact and determine the effectiveness of decisions taken at the project selection and project levels. Pavement performance depends on many parameters, including construction quality, materials, environment, drainage, traffic, and the interaction of these parameters. Shivakoti and Soleymani presented a methodology to address the issue of optimum decision-making and uncertainty analysis. Goals of the proposed methodology included enabling the decision-maker to optimize budget allocation and providing the decision-maker with multiple optimal solutions in order to balance the objective function and the impact of uncertainty on the optimal solution.

## Upcoming Events

### Pavement Preservation Seminar
### October 3, 2006 – Austin, Texas

The Pavement Preservation Seminar, scheduled for October 3, 2006 in Austin, Texas, will present a thorough overview of the latest concepts, techniques, and materials related to pavement preservation. Seminar topics will include Asphalt Overlays, Scrub and Fog Seals, Crack Sealing Techniques and Materials, Chip Seal Best Practices, TxDOT Questions and Answers, Hot-in-Place Recycling, Micro-Surfacing and Slurry Seals, and Pavement Management Systems. In recognition of the need for education and training related to pavement preservation, AGC, AEMA, $FP^2$, and the Texas Pavement Preservation Center will collaborate in conducting the 2006 Pavement Preservation Seminar. The 2006 Seminar will be presented in conjunction with the 23rd Annual AGC of Texas Trade and Equipment Show.

***For updates visit the Texas Pavement Preservation Center (TPPC) website: www.utexas.edu/research/tppc.***

## Our Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost.

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THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COLLEGE OF ENGINEERING

TEXAS PAVEMENT PRESERVATION CENTER

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## 2006 Pavement Preservation Seminar
## October 2-3, 2006 - Austin, TX

### Presented in Conjunction with the 23rd Annual AGC of Texas Trade & Equipment Show

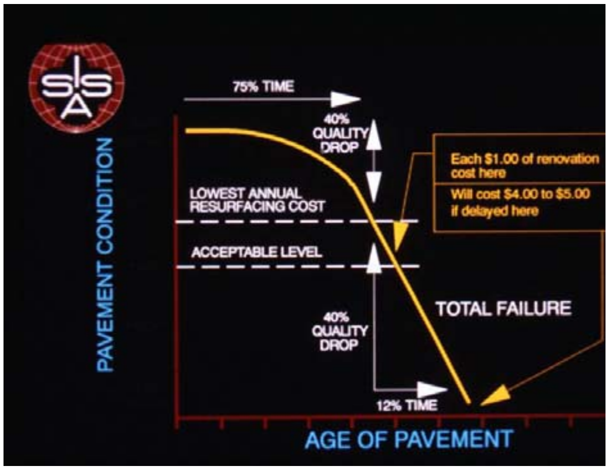
The 2006 Pavement Preservation Seminar was held on Monday and Tuesday, October 2-3, 2006 at the Austin Convention Center in conjunction with the 23rd Annual Association of General Contractors of Texas Trade & Equipment Show.

Sponsors for the Seminar were the Asphalt Emulsion Manufacturers Association (AEMA), the Associated General Contractors of Texas (AGC), the Foundation for Pavement Preservation ($FP^2$), the Texas Department of Transportation (TxDOT), the Texas Pavement Preservation Center (TPPC), and the UT Center for Lifelong Engineering Education (CLEE).

The seminar offered an excellent overview of the concepts, techniques and materials involved in pavement preservation, with a particular emphasis on preventive maintenance. Seminar topics included asphalt overlays, scrub and fog seals, crack sealing techniques and materials, chip seal best practices, recycled asphalt pavement, hot-in-place recycling, micro-surfacing and slurry seals and pavement management systems.

The seminar offered an excellent overview of the concepts, techniques and materials involved in pavement preservation, with a particular emphasis on preventive maintenance. At the conclusion of the Seminar, attendees were invited to a luncheon, followed by the opening of the 24th Annual AGC of Texas Trade & Equipment Show.

## Barry Dunn – **Micro-Surfacing and Slurry Seals**




Barry Dunn presented on the best practices for micro-surfacing and applying slurry seals. Dunn defined conventional slurry seal as a designed mixture of emulsified asphalt, mineral aggregate, water and specified additives, proportioned, mixed and uniformly spread over a properly prepared surface. Historically, slurry sealing has been done in residential areas and served about the same purpose as single chip seal or single seal coat but without the undesirable characteristics of dust, tracking asphalt or loose rock. Dunn said that, with a lot of thin layer treatments, the aesthetics and success of the project have much to do with condition of a pavement. He stressed that the thin layers don't build a structure, or repair base failures, but rather preserve and prevent future deteriorations.

Slurry Seals have two primary uses: 1) preventive – to prevent surface deterioration and 2) corrective – to renew surface properties.

Preventive maintenance protects the existing pavement from the effects of ageing and weathering, thereby extending and maximizing the existing pavement's service life. Dunn stated that, if all funds are spent on the worst roads first, the money will be exhausted quickly and good roads will fall into fair conditions and fair roads into poor conditions.

The types of services slurry or micro-surfacing can provide for corrective maintenance are restoring or renewing desirable surface properties such as skid resistance, crack filling, weather proofing, surface loss of matrix or raveling, aesthetics, uniformity of surface, and leveling or rut filling.

Slurry Seal can, in one pass, deposit a bituminous seal according to the surface demand; fill the interface crack, place a modest wedge if the shoulders are low, place a weather tight seal, fill the surface voids, and provide color/texture delineation and high friction surface.

Slurry seals may be used as a part of a preventive maintenance program, but Dunn warned that slurry seals will not stop reflective cracking. How much slurry costs and how long it will last depend directly upon the condition of the existing pavement.

The difference micro-surfacing has from slurry seal is that micro-surfacing is a designed mixture of polymer modified emulsified asphalt. For each inch of applied micro-surface mix add 1/8 to 1/4 inch crown to each rutfill to compensate for return traffic compaction. Ruts with less than 1/2 inch may be filled with scratch course.

In conclusion, Dunn advised the use of slurry seal or micro-surfacing to weatherproof and delay age hardening caused by oxidation to maximize the life of existing asphalt pavements. In doing corrective maintenance, he advised to always define the cause of the defect, to correct the cause, and then correct the defect.

## Joe Graff – **Texas Pavement Preservation Center**

Joe Graff presented at the Texas Pavement Preservation Center. Graff talked about pavement preservation, the development of the center and the services offered by the center.

Pavement condition deteriorates over time with a lot of traffic. Historically, many states wait until conditions get poor, to the point where they have to use reactive maintenance. Pavement preservation maintains pavement at a high level of service.

The goals of establishing the Texas Pavement Preservation Center are training, technology transfer and research implementation. Training includes new courses on pavement preservation, online courses and onsite training courses. Target audiences of the center are administrators, policy-makers, engineers and construction workers. Graff talked about highlights of the center and mentioned that its 1st training course would be offered on seal coat and would include topics such as roadway selection guidelines, materials selection, preconstruction activities, performance monitoring, etc.

The Texas Pavement Preservation Center is available to provide on-site training/demonstrations, online training, research and implementation.

## Jim Brownridge – "**Reclamite" Preservation Seal**

West Coast Rejuvenator Application

Brownridge defined pavement preservation as a process of utilizing time proven preventive maintenance activities to extend the useful life of asphalt pavements and to lower annualized resurfacing costs as well as future resurfacing costs. Asphalt rejuvenators can be a maintenance department's lowest cost surface treatment alternative to extend pavement life. Asphalt

consists of two main fractions: aslphaltenes—which are the hard brittle insoluble component, unaffected by oxidation and the highly reactive sub-fractions— and maltenes—which are oily and resinous in appearance.
An asphalt rejuvenator is a manufactured product, which has the ability to absorb or penetrate into the pavement and restore those reactive components that have been lost due to oxidation. Rejuvenators are manufactured as emulsions, typically 60-65% residual. They have the ability to “wet” the asphalt binder that is present.
An asphalt rejuvenator increases the penetration value of the asphalt cement in the top portion of the pavement, which extends the pavement’s lifecycle, seals pavement against intrusion of air and water and thereby slows oxidation, preventing stripping and raveling, and protecting the pavement in-depth.
In conclusion, Brownridge stated that the “Reclimite” reverses the aging of asphalt pavements through in-depth correction of the asphalt’s chemistry.

### Dar Hao Chen — **Identification of Reflection Cracking**


Reflection cracking depends on the underlying and outer layer. In the underlying layer, cracking happens when there is movement induced by traffic, moisture or temperature. The question is how to determine what pavement has risk for reflective cracking. In order to do that, proper tools are needed to analyze movement.
Reflection cracking is the biggest problem in HMA overlays of PCC pavement. Crack retarding layers can bend very well as opposed to a polymer modified superpave mix, which can break easily. A crack retarding layer uses very high asphalt content, fine aggregate and is very dense. The problem with a crack retarding layer is that it is very soft with a thick asphalt on top that causes rutting to occur when a truck goes through. This material is also roughly twice the cost of a conventional mix.
Chen talked about an upgraded Overlay Tester that is fully computer-controlled to help design mixes that resist reflection cracking.
A rolling dynamic deflectometer (RDD) is an operational device, which can give continuous deformation. This device, which travels 1 mile per hour, is owned by The University of Texas at Austin and is the only one in the world. With the use of RDD, continuous deformation can be obtained to help identify risk for reflective cracking.

Based on the results obtained, the RDD and OT provide an objective evaluation that correlates to field performance data.
Chen strongly recommended that both tools be used for the rehabilitation of concrete pavement with an HMA overlay to evaluate the potential risks for reflective cracking

### John O’Doherty — **Pavement Preservation: Preservation National Perspective**

John O’Doherty presented the topic of the national perspective of pavement preservation and the pavement maintenance life cycle cost analysis.
O’Doherty defined pavement preservation as an applied asset management that combines engineering with business and economic theory. The traditional reconstruction and rehabilitation initiates life, whereas pavement preservation extends life.
The original pavement deteriorates slowly, eventually hitting a preventive trigger, at which point minor change, preventive maintenance is done to restore it to its original condition and extend the life of the pavement.
According to the pavement option curve, pavement quality drops 40% in the first 75% of a road’s life, and, in the next 12% of its life, the quality drops another 40%, therefore spending $1 before a pavement’s condition drops significantly eliminates or delays spending $6 to $10 on rehabilitation or reconstruction in the future. O’Doherty explained pavement management basics using a pavement serviceability index.
O’Doherty’s example on the quick assessment method of network evaluation establishes a network need, evaluates reconstruction, rehabilitation and preventive maintenance, and also incorporates design life with life extensions.
In conclusion, pavement preservation is a “decision” that will improve highway network condition at lower cost, and failure to adopt pavement preservation may have financial consequences.

### Garry Fitts – **"PMA Applications and Performance"**

Garry Fitts spoke about applications of polymer modified asphalts (PMA), their performance compared to neat asphalt, particularly hot-mix, and practical/construction issues.

The main reason why asphalt is modified is to change the temperature effects on asphalt's physical properties; that is, to make asphalt stiffer at high service temperature and stronger at low-intermediate service temperature. In addition, modifying asphalt improves adhesion to aggregates and reduces effects of aging/oxidation on asphalt properties.

Some of the applications for PMA include seal coats, micro-surfacing, interlayers, dense-graded HMA, permeable friction course and stone matrix asphalt.

Applications for PMA have become wider and begun spreading to local governments as well.

A study on PMA Performance in Hot Mix Asphalt was performed by ARA for the Asphalt Institute and Association of Modified Asphalt Procedures, to compare the performance of polymer modified asphalt with comparable sections built with neat asphalt. The objective of the study was also to identify conditions that maximize the effects of PMA to increase HMA pavement and overlay life. The findings of this study suggest that the 25% and up increase in service life can be assumed using PMA mixes, along with 3 to 10 years increase in service life and reduced maintenance.

In conclusion, Fitts said that the use of PMA mixes extends the service life compared to unmodified HMA mixes, and that layer thickness should not be reduced when empirical thickness design methods are used.

### Tom O'Leary – **"Seal Coats for Pavement Preservation"**


O'Leary gave a thorough overview of seal coat best practices. A seal coat is generally a single, double, or triple application of asphalt material covered with aggregate. Surface treatments are applied to prepared base courses or other surfaces. Seal coats are applied to existing pavements to extend the life of the pavements, but they are not intended as permanent pavement surfaces and have a life expectancy of approximately five years. The service life of a seal coat varies depending on situational conditions such as traffic volume and weather. Seal coats correct deficiencies such as cracks, raveling (or shelling), bleeding, aged or oxidized pavement, low skid resistance and also provide the appearance of a uniform surface. Seal coats, however, will not strengthen existing pavement, increase load-bearing capacity, smooth out rough pavement, bridge major cracks wider than 1/8" (cracks wider than this size must be crack sealed in advance), or eliminate the need for maintenance or reconstruction. Within the first three-quarters of the life cycle of a pavement, there is a 40% reduction in quality, but, in the following 12% of the life cycle, the quality of the pavement plummets into total failure. Thus, a seal coat should be applied during this initial three-quarter period. Some factors affecting seal coat quality are existing pavement surface condition, the experienced capability of workers applying the seal coat, equipment, materials, application technique, traffic, and weather. A raveled surface will require more binder; a slick surface will require a lighter binder and bleeding pavements a lighter application rate.

Seal coating is an art, not a science, and seal coat design is simply a starting point: be prepared to deviate from the design. It is necessary to have a good eye once you get out onto the road. The contractor superintendent, engineer designer, inspectors, operators, suppliers and taxpayers all play a role. Inspectors need to be adequately trained and have the freedom to make timely and informed field decisions. They need to develop partnering relationships with the contractor and suppliers and understand that plans are only a guide and that each road requires special considerations.

Before applying a seal coat, an old roadway should be patched, crack sealed, and thoroughly cleaned. Likewise, unpaved surfaces need to be primed unless inverted prime techniques are being used. Keep in mind that hot or cold mix patches need adequate curing time. If this is not possible, then a fog seal should be considered instead of a chip seal. Herbicide should be applied to surrounding vegetation, and gutter areas and curbs should be vacuumed, particularly in urban environments.

To prepare for seal coating, it is necessary to calibrate equipment, know proper design rates, understand factors affecting rate adjustments, determine rock lands, strap the distributor for accurate readings, and ensure that proper signing and traffic control are in place. Calibrate the distributor's spray bar height, nozzle angle, spray bar pressure, and computer or asphalt meter. A double coverage spray bar is most commonly used; a triple coverage spray bar is not recommended because it is susceptible to wind, which will affect binder consistency. Computer-controlled aggregate spreaders need to be calibrated for proper rate distribution, and the gates and hitch need to operate properly. The shot should be set to the size of the aggregate rather than the size of the distributor so that binder gets covered in a timely fashion. Stockpiles should be placed in strategic locations for better production.

It is extremely important that trained operators drive the aggregate spreader at a controlled ground speed to reduce skids and prevent rock from turning over. It cannot be overemphasized that the aggregate spreader should never move faster than the distributor. The spreader box should be directly behind the distributor (the quicker the aggregate gets applied, the better the bond will be). On high heat afternoons, however, the spreader box should back off slightly.

Trucks should be of adequate size and quantity. Measure and record the volume within each truck. Control the trucks' speed throughout the project. Stagger the dump trucks in and out of the wheel paths or station them down the roadway. Check tires periodically for proper inflation and cleanliness.

Rollers should be pneumatic only (three medium or four light pneumatic rollers are recommended), and tires should be clean and properly inflated. Rolling must take place immediately after the spreading of aggregate. The slower the roller moves the better, and rollers should always be moving because if it is sitting, it will squeeze aggregate down and push binder up. When a job is delayed for more than 10 minutes, rollers and trucks should be moved off of the fresh seal.

For traffic control, flagmen, signs, and a pilot car are needed. The flagging stations should be constantly moved, and the pilot car should maintain slow speeds. Traffic control should also clean up messes; clean-up must be done immediately because on a hot day, a mess will get tracked through the whole job.

The proper aggregate for seal coating should be clean, single-sized, and cubical for optimum performance; avoid flat particle shapes and uncrushed gravel since these do not offer skid resistance. Do not use pre-coated aggregate with emulsion binder because it has a tendency to dramatically slow the break of the emulsion and will stay tender for a very long time. Pre-coated aggregates should only be used with hot AC binders. The cost of single-sized aggregate deters their usage in most states, but a method to determine the number of "flatter" particles should be used when using graded aggregates. Aggregate with minimal fines should be used since fines will settle at the bottom if there are too many in the mix, preventing the proper embedment of larger aggregate into the binder and resulting in the loss of cover stone and bleeding. Natural and synthetic aggregate can be used. Aggregate selection depends on the type of roadway, volume of traffic, existing weather conditions, availability of aggregate, and cost.

Voids are the spaces between the aggregate particles; as aggregate particles are dropped into wet asphalt settling should occur in disoriented positions. After rolling and traffic, aggregate will be seated in their flattest position. Voids should account for 20-30% of the area before rolling and should account for roughly 20% of the area after rolling. For good performance, voids should not be filled completely with asphalt binder. On low volume roads, voids should generally be 40-50% full. On higher volume roads, voids should be only 30-40% full. Hot AC is typically applied at 320-350°F. Hot AC loses 150-200°F in the first 30-45 sec. after application, so it is imperative to apply aggregate on AC while it is still very hot. The more fluid the binder is, the better it will adhere to the aggregate. Application of aggregate should be one rock thick, and if aggregate is applied correctly, there should be little or no remaining excess to sweep after a job.

To avoid excess joints, asphalt should be applied to the entire area of intersections and widenings first before applying aggregate. Paper the joints at all starting and stopping points, and shoot on clean surfaces only. Use 1/2 nozzles or end nozzles on longitudinal joints. Nozzles should never be squared because doing so will actually produce a double shot; two nozzles are needed for a proper shot.

Marginal surface temperature requires excellent construction techniques. Do not shoot too late in the day if working under questionable weather conditions; there needs to be plenty of time for proper curing before nightfall, since it is typically the wet or cold nighttime conditions that will ruin a seal coat.

Operators are often under pressure to get a job done and may be inclined to rush. Under these conditions, when tracking occurs, the first instinct is to raise the aggregate rate. This is the wrong thing to do. In reality, trimming the rock rate will stop the tracking. Aggregate rate is extremely important and affects more than just the look of the road. Too much aggregate will cause binder to push up.

In a high traffic situation, skid marks occur where trucks have to stop for traffic. An innovative way to solve this problem is to break up the application. Shoot three miles, and then skip a shot for the next 3,000 feet. This way, traffic always starts and stops on the old surface. At the end of the day, fill in the parts that were skipped. By doing this, skid marks can be avoided and patching will be unnecessary. In a day, one transport load of production may be lost, but no patching will be required.

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### John Christensen – **"Asphalt Production"**

John Christensen talked about how to get asphalt from crude refined products. Almost all asphalt comes from crude refined petroleum. Crude varies widely depending upon viscosity, sulfur content with low sulfur specifications as required by environmentalists, and asphaltenes. Three types of crude variables are Venezuelan, Arabian-Heavy, and Nigerian-Light.

Typical refining runs between 50 to 300,000 barrels per day. Crude is heated up to 650-700°F, then injected into Crude Tower at which point crude boils, and gas starts to rise up to the top of the tower as liquids fall into the bottom. Kerosene, light gas oil, and heavy gas oils are then condescended out of the tower through appropriate plates. All of these are then inject into the Vacuum

Tower to pull out all the remaining air so that thermal cracker and coker come out from the Vacuum Tower Bottom asphalt. Asphalt that comes out of Vacuum Tower is blended with Pitch and some heavy oil making base asphalt for pavement.

Asphalt molecules consist of asphaltenes, which have components such as polar aromatics, naphthalene aromatics and saturates. Asphaltenes are the largest, heaviest molecules, and give the asphalt its solid nature at room temperature.

Asphalts are graded by the temperature they resist distresses according to Performance Graded (PG) specifications. The reason modified asphalts are produced is to increase the performance of one criteria (criteria for rutting, fatigue and thermal cracking) without losing another, and this is usually done by increasing the PG temperature spread.

Most commonly used elastic modifiers are stryrene butadiene stryrene (SBS), tire rubber (TR), latex (SBR) and reactive elastometric terpolymer (Evaloy). SBS and tire rubber are elastic modifiers mostly used in Texas.

SBS is thermoplastic elastomer polymer, which consists of thermoplastics that have properties such as melting when heated and hardening when cooled, while still recovering properties when heat is removed. Additionally, SBS consists of elastomers, which exhibit elastic properties that return to original shape when stress is removed. SBS is thermoplastic elastomer that exhibits properties of thermoplastics and elastomers in the same molecule.

Polymer modified asphalt production starts with low temperature, followed by introducing and milling polymer. By agitation and heating processes, SBS molecules are dissolved and linked, and, in the final process, PG grading, homogeneous asphalt and consistency are sought.

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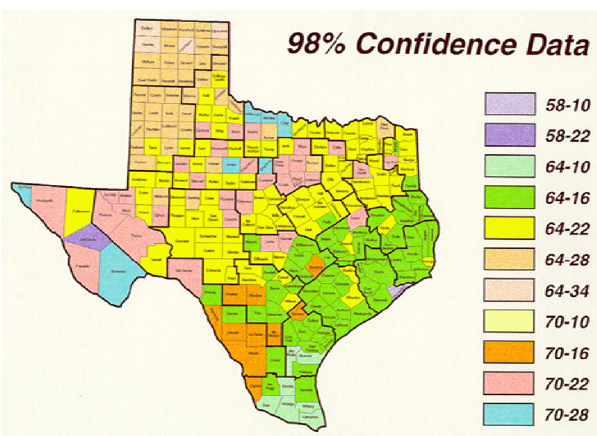
Darren Hazlett – **"Asphalt Binder Selection"**




PG binder specific grade selection is based on a climate based grade that can be developed by the computer program and maps that were created by TxDOT, and it is also based on changes to high temperature designation.

Loading rates that were assumed when building a highway are relatively low when there is a traffic jam, which is why there has to be change in PG grading according to the speed and volume of traffic.

Surface layers are very important to concentrate in terms of when changes to high temperature occur, because, when the weather is hot and traffic is heavy, the surface layer binder is expected to resist the failure.

Hazlett talked about the materials used in surface treatment, including modified and unmodified hot applied binders and emulsions. Hot applied binders are 100% binder. Road to the traffic can be opened on hot applied binders as soon as the rock is rolled and the binder has cooled. Some of the disadvantages of hot applied binders are that they must be applied at high temperatures which can be dangerous for field personnel. Also, hot applied binders do not work well with wet or dusty aggregates and therefore usually require pre-coated aggregate. Emulsions, on the other hand, require more elapsed time before opening to traffic and are applied at a lower temperature than hot applied binders. Polymer modified versions of hot applied binders and emulsions help early chip retention, handle higher traffic volumes, and perform in wider temperature extremes.

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Brett Budris **– "Crack Sealing"**

Budris presented an overview of crack sealing. According to an FHWA report, potholes and additional cracking form at 75% to 80% of unsealed cracks compared to 1% of sealed cracks (FHWA/UT-85/1). The Utah DOT also found that effective crack sealing significantly reduces the pothole formation and development of additional cracking.

The importance of crack sealing is that it prevents water intrusion into sub-base, prevents incompressible intrusion and results in pavement humping, improves ride quality and smoothness, and extends pavement life by slowing down deterioration.

Crack sealing application procedures for training, which were put together by TxDOT and UT-Austin, includes setting up proper traffic control, routing cracks if needed, cleaning and drying the crack before applying the treatment and allowing material to cool before opening to traffic.

Bud Smallwood – **"In-Place Recycling of Asphalt Pavement Projects"**

Smallwood presented in-place recycling of asphalt pavement projects in University Park. He gave thorough information about the town and the projects done in the town.

Smallwood stated that one of the benefits of in-place recycling to the residents is the short process of applying in-place recycling.

Based on the pavement lifecycle cost per year diagram, the cost of pavement service had dropped from $4.93 in 1992 to $0.35 per yard in 2006.

Steven Muncy **– "Cold Recycling and Cold-in Place Recycling"**

Cold in-place recycling is useful because it is environmentally sound, gives enhanced performance and is cost effective. Cold in-place recycling is a straight forward process, in which existing asphalt pavement is pulverized, reclaimed asphalt is sized, the addition of new asphalt binders and the mixing of all component materials are then placed and compacted.

There are a variety of equipment and ways of putting cold in-place recycling units together. A multi-unit train has liquids, modifiers, emulsions in the front, and a milling machine, pressuring unit, pugmills and compaction equipments that follow.

All reclaimed asphalt pavement (RAP) is screened to a maximum size requirement, and the oversized material is crushed and returned to the screen deck for total sizing control.

Cold in-place recycling mix design procedure includes obtaining sample of reclaimed asphalt pavement from field; determining RAP gradation, binder and aged binder properties; selecting amount and gradation of additional aggregate; selecting type and grade of recycling additive; and also testing trial mixtures.

Selection of additives depends on type of soils, aggregates and, among the bituminous additives, asphalt emulsion (with or without polymer) is in the biggest use.

From chemical additives, Portland Cement and Hydrated Lime have been used in conjunction with asphalt emulsion to improve early strength, increase rut resistance and improve moisture resistance.

Thermal cracking, poor rideability, raveled pavements, and fatigue cracking are good candidates for CIR.

There are many CIR benefits: CIR conserves energy and materials, it improves mix characteristics, it eliminates or reduces cracks; it improves geometrics and most importantly it is cost effective.

Muncy stated that the weather condition is not the big factor in considering CIR, except for a lot of rain.

***Watch the video of the 2006 Pavement Preservation Seminar proceedings at www.utexas.edu/research/tppc/conf***

**Upcoming event**

**MNT704 - Seal Coat Design, Construction, and Inspection**

This course will provide engineering guidelines for planning, desiging, constructing, and inspecting seal coats. Specifically, the course will cover roadway selection, materials selection, material specification and test requirements, plan preparation, inspector duties and authority, equipment inspection and calibration, seal coat design methodologies and field adjustments, inspection requirements, construction process, and performance monitoring.

***For updates visit the Texas Pavement Preservation Center (TPPC) website: www.utexas.edu/research/tppc.***

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COLLEGE OF ENGINEERING

TxDOT

# TEXAS PAVEMENT PRESERVATION CENTER Newsletter

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**Spring 2007 / Issue 6**

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## Issue Highlights

### TRB 86th Annual Meeting

The TRB 86th Annual Meeting is an information-packed program that attracted approximately 10,000 transportation professionals from around the world to Washington, D.C., January 21-25, 2007. The meeting program covered all transportation models, with more than 2,800 presentations in 500 sessions addressing topics of interest to all attendees – policy makers, administrators, practitioners, researchers, and representatives of government, industry and academic institutions. The spotlight theme for 2007 was "*Transportation Institutions, Finance, and Workforce: Meeting the Needs of the 21st Century*".

### 2007 Smart Highways CTR Symposium

The Center for Transportation Research at the University of Texas at Austin hosted its annual symposium on April 4, 2007. The theme of this year's symposium was "Smart Highways" with keynote speaker, Gregory Krueger – manager of the Statewide ITS Program for Michigan DOP, addressing a subject on highway construction costs, particularly recent developments and the outlook.

### Mark Your Calendar:
### 2007 Pavement Preservation Seminar

The 2007 Pavement Preservation Seminar will be held on October 8-9, 2007 at the Austin Convention Center in conjunction with the 24th Annual Association of General Contractors of Texas Trade & Equipment Show. Sponsors for the Seminar are the Asphalt Emulsion Manufacturers Association (AEMA), the Associated General Contractors of Texas (AGC), the Foundation for Pavement Preservation ($FP^2$), the Texas Pavement Preservation Center (TPPC), and the UT Center for Lifelong Engineering Education (CLEE).

**Evaluating Minnesota Crack Sealants by Modified Bending Beam Rheometer Procedure** by James McGraw, John Olson

ASTM D 6690 crack seal specifications do not accurately predict field performance for cold weather climates like Minnesota. Under low temperature conditions, crack sealants which meet ASTM D 6690 specifications exhibit poor adhesion and cohesion, greatly compromising the effectiveness of this treatment. As a result, the Minnesota Department of Transportation (MnDOT) is conducting research to establish guidelines for sealant use in Minnesota. This study evaluates low modulus hot-pour sealants developed for Minnesota's climate through use of the modified Bending Beam Rheometer test (BBR) - a method created by the U.S.-Canada Crack Sealant Consortium. Results of this study indicate that the method created by the U.S.-Canada Crack Sealant Consortium can successfully be tested by state DOTs in local laboratories; this method includes Creep Stiffness, Creep m-value, and Creep Rate tests. Research indicates that measurements provided by the three test measures offer a more comprehensive approach than ASTM tests - yet to reap benefits of this methodology, it is necessary that researchers apply more than one of the above mentioned testing measures. After applying these test methods, MnDOT was able to identify differences between low modulus crack sealants and draw comparisons with these and ASTM Type II products. Research indicated that some ASTM Type II sealants, suggested by the ASTM D 6690, may perform to the same level as low modulus products. Once the US-Canada Crack Sealant Consortium sets performance parameters on its modified BBR testing methods, a crack sealant performance-based grading system can be established.

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**Low Temperature Characterization of Hot-Poured Crack Sealant Using Modified SHRP Direct Tensile Tester** by Imad Al-Qadi, Shih-Hsien Yang, Samer Dessouky, Jean-Francois Masson

In this study, Imad L. Al-Qadi et al. examined new methods for predicting low-temperature performance of hot-poured crack sealants. Previous research indicates that predictive performance models of crack sealants do not accurately account for low-temperature conditions, where these treatments usually fail in adhesion and/or cohesiveness. The proposed method attempts to address low temperature field performance by assessing polymer-modified sealant and sealants containing crumb rubber. Testing methods modified the Direct Tensile Tester (DTT) practices to examine hot-poured crack sealant's properties. Researchers developed a means to define optimum specimen size for testing. This contributed to both improved accuracy and repeatability of this study. Additionally, this study set parameters on the suggested loading range - 1.5 to 3mm/min for this material. Results of this study suggest that polymer-modified sealant has better ductility and strength than sealants containing crumb rubber.

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**Repeatability and Reproducibility of the Newly Developed Hot-Poured Bituminous Sealant Viscosity Test** by Imad Al-Qadi, Eli Fini, Mostafa Elseifi, Hector Fiqueroa, Jean-Francois Masson, Kevin McGhee

Hot-poured bituminous asphalt used in crack sealing and filling is an important pavement maintenance technique. When properly applied, this treatment prevents water and debris from accessing pavement structure - extending pavement life at a low cost. The success of this treatment largely depends on the installation process. Factors such as sealant penetration of pavement overlay (HMA), its ability to fill cracks/voids, as well as follow surface irregularities, each play a part in adhesion and bonding of the sealant to the pavement structure. Until recently, sealant testing methods defined by ASTM and AASHTO have relied on empirical data; these measures often did not correlate with field performance. New methods aim to predict field performance by controlling sealant installation processes; these methods monitor the sealants' viscosity levels during installation - a condition which affects the sealant during installation as well as the treatment's bond strength. Al-Qadi et al. aimed to validate the repeatability and reproducibility of the new testing method. The team used statistic analysis of sealant testing within and between seven laboratories investigating this field performance measure. They determined that the new testing method is acceptable with only slight variations of 1.6% within laboratories and 6% between laboratories. This measure is similar to that used for asphalt binders at 3.5% and 14.5% respectively based on ASTM D4402-02 and 3.5% and 12.1% based on AASHTO 2006 T316. Upper and lower limits of viscosity will be determined after further testing of the adhesion strength of crack sealants to aggregates.

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**Characterizing Existing Surface Condition to Evaluate Chip Seal Performance** by Douglas Gransberg

According to Douglas Grasberg, many North American highway agencies are overly invested in the belief that chip seal application is unpredictable. Grasberg counters that existing pavement assessment methods can determine if chip seal is the proper treatment and indicate factors which contribute to the premature aging of the treatment. Specifically, Grasberg calls for quantitative and qualitative analysis of pavements prior to and after treatment, claiming this method can lead to increased predictability of chip seal application. In this study, Grasberg analyzed chip seal use on rural roads in Texas. The research analyzed pre- and post-sealed pavements with the qualitative windshield survey, the Texas Department of Transportation Pavement Management Information System ratings, and the quantitative Transit New Zealand T/3 "sand circle" test

(TNZ T/3). This combination of tests allowed the researcher to analyze the impact of texture depth of the substrate on the success of chip seal treatments. Conclusions at the early point of this study indicate strong correlations between pavement substrate and the success of chip seal treatments. Most significantly, this research indicates that premature texture loss of chip seal treatments occurs at a faster rate when applied to pavements with a high occurrence of flushing. This research may help determine if chip seal is the appropriate preservation technique. Additionally, the methodology of this study offers practitioners a more comprehensive means to assess the cause of treatment failure, whether it results from pre-seal pavement conditions or the chip seal product. Overall, this study implies that use of engineering measurements and characterization of pre-seal pavement can predict premature chip seal failure.

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**Cost-Effectiveness of MIrcosurfacing and Thin Hot-Mix Asphalt Overlay: Comparative Analysis** by Samuel Labi, Mohammad Mahmodi, Chuanxin Fang, Charles Nunoo

Using pavement management data from Indiana, this team comparatively analyzed cost-effectiveness of microsurfacing and thin hot mix asphalt (HMA) overlays. Major considerations for the cost-effectiveness included treatment susceptibility to climate severity and traffic loading. Measures of Effectiveness (MOE) included treatment service life, increase in pavement condition, and area bounded by performance curve. Mircosurfacing, a treatment which mixes polymer-modified asphalt emulsion, crushed mineral aggregate, mineral filler, and a hardening control additive immediately prior to laying, proved to be generally more cost-effective than HMA overlay. When considering the first MOE, treatment service life, microsurfacing was 51-59% more cost-effective than HMA overlay, despite having a shorter service life. This was most apparent in situations with low traffic loading and high climactic severity. In the second MOE, increase in pavement condition, microsurfacing appeared more cost-effective under all conditions except those with both high traffic volume and high climate severity. Finally, the third MOE, area bounded by performance curve, demonstrated that microsurfacing was 54-71% more cost-effective than thin HMA overlays, regardless of traffic or climatic conditions. These findings can guide cost-driven decision making, providing relevant information to highway agencies and informing practices.

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**An Investigation of Prime Coat Effectiveness in Surface Treatments Constructed on Base** by Vignarajah Muthulingam, Sanjaya Senadheera

Muthulingam and Senadheera tested the effectiveness of prime coats on flexible granular base materials used in Texas highways. The role of the prime coat as both the "glue" which fuses a base material to its surface treatment and sealant which prevents moisture or dust from affecting the base material is crucial for creating cost effective pavement surfaces. In this experimental study, Muthulingam and Senadheera looked to assess the influence of base material, base surface finish, and moisture content of the base layer on prime coats through measuring prime penetration, pullout strength of the prime and flexural strength of the primed base. This study addressed the most common means of prime coat application in Texas, namely spray prime, worked-in prime and covered prime, as well as base finishing techniques such as blade and roll, slush roll, trimming, and laydown machine. The results of this study concluded that the effectiveness of prime coats depends on a number of factors, including its penetration, prime coat binder, and prime coat techniques. In light of these complex relationships, more research is necessary to develop a protocol for prime coat application. Already this team noted that the optimal base moisture condition varies as a result of base material, surface finish, and the prime coat binder.

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**Evaluation of the Performance of Recycled Asphalt Sections in California Environmental Zones** by Sameh Zaghloul, Joseph T. Holland, Amir Abd El Halim

California Department of Transportation (CalTrans) initiated a study to evaluate in-service pavements in California. In this study, researchers collected data on the field performance of special materials, like Rubber Asphalt Concrete (RAC), Recycled Asphalt Pavement (RAP), and Pavement Reinforcing Fabric (PRF). This paper analyzed the RAP field performance data collected in this study. Sixty RAP sections were selected which encompass a total of three of California's environmental zones-namely Desert (DS), Mountain (MT), and North Coast (NC). According to Zaghloul et al., researchers evaluated field performance by measuring in-situ structural capacity, pavement distress condition, roughness condition, and consistency of construction. Through use of Falling Weight Deflectometers (FWD), the International Roughness Index (IRI), distress surveys and laboratory testing of core samples, researchers developed deterioration models to predict pavement service life. Researchers concluded that RAP sections located in the North Coast will be triggered by ride quality after 17 years; other factors like structural capacity and distress indicate that RAP sections will remain in service for 18 years and 21 years respectively. Under Desert conditions, researchers predict that distress will trigger RAP sections after only 9 years; however, regular maintenance can extend the predicted service life up to 15 years. Similarly, factors like structural capacity and roughness were predicted to trigger pavements exposed to Desert conditions after 15 years. Under Mountain conditions, researchers anticipate structural capacity to trigger pavements after 11 years, distress after 13 years, and roughness after 15 years. Overall, North Coast pavements exhibited the highest performance level, possibly resulting from use of cement treated base material. This material has a higher modulus than typical aggregate base course. However, since only five North Coast sections were analyzed, these results are inconclusive. Further analysis will compare RAP performance with other treatments or materials.

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**Long-Term Field Performance of Cold In-Place Recycled Roads in Iowa** by Jungyong Kim, Hosin Lee, Charles Jahren, Dong Chen, Michael Heitzman

For more than two decades, United States roadway managers have selected Cold In-place Recycling (CIR) to rehabilitate primary and secondary asphalt roads. This method proves to perform well at a low cost, yet few long-term performance studies have suggested methods for predicting service life. In this study, Kim et al. examined CIR roadways in Iowa. This team aimed to develop a performance model for CIR to predict service life and indicate key environmental characteristics which impact CIR performance. The team created an inventory of all CIR roads in Iowa, taking into account construction information, subgrade and base characteristics, and traffic levels. After considering these factors as well as pavement age, 26 test sections were selected. Test sections were subjected to a pavement condition survey using Automated Image Collection System (AICS) and results were combined with distress or rutting data to create the Pavement Condition Index (PCI). This index along with measurements of subgrade soil support and core samples of the pavement allowed researchers to analyze and identify key contributing factors of CIR longevity. Results of this study indicate that subgrade support greatly impacts CIR performance. This study implies that subgrade support impacts service life more than traffic volume. Additionally, low levels of support correlate with higher incidences of rutting, patching, and edge cracking. These factors along with others predict a longer service life of CIR pavements with good subgrade support; pavements with good support have a predicted service life of up to 34 years, while those with low levels are predicted to last up to 22 years. This research recommends that future CIR studies focus on pavement core samples, as this would enable researchers to better understand causes of distress within the CIR layer. Additionally, it suggests pavement test sections be reevaluated in five years to verify predicted service life.

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**Evaluation of Long-Term Performance of Cold In-Place Recycled Asphalt Roads** by Dong Chen, Charles Jahren, Hosin Lee, R. Willams, Sungwan Kim, Jungyong Kim

Dong Chen et al. examined Cold In-Place Recycling (CIR) performance in Iowa. The goal of this study was to quantify the effect of aged-engineering properties and impact factors such as age, traffic, and support on CIR performance. The team selected 24 CIR roadways throughout Iowa which vary in age, traffic, and support conditions. Roadways considered in this study were constructed between 1986 and 2004. Researchers analyzed this data set through use of field distress surveys, field tests, laboratory tests, and statistical analysis. Results of this study concluded that the modulus of the CIR layer and the air voids of CIR asphalt binder have the greatest effect on CIR performance under high traffic conditions. Additionally, this study supported the theory that CIR layer is a stress-relieving layer and suggested that less stiff and more porous CIR pavements can best fulfill this role. Within the scope of this study, results suggested that higher values of Indirect Tensile Strength have a positive affect on CIR performance under low traffic conditions, while higher traffic conditions were associated with lower levels of CIR performance across the board. Finally, this research did not find support conditions of pavement to be a significant performance variable. Researchers suggest future efforts analyze a larger sample size, approximately 50 test sections, and reduce the variability of the response variable, relative Pavement Condition Index (PCI), by taking more core samples and increasing use of the Falling Weight Deflectometer (FWD) test. With sufficient information, future research will better distinguish between effects of HMA and the CIR layer. Also, it is suggested that phase angles be taken into consideration to account for the elastic and viscous properties of asphalt binders.

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**Road Maintenance Practices in Malaysia** by Tahir Ahmad, Juraidah Ahmad, Mustaque Hossain

Tahir Ahmad et al. examined the privatization of federal roadway maintenance in Malaysia. This practice, compared with its public agency counterpart, has fundamental differences in administration and execution of maintenance procedures. Private maintenance agreements are performance based; this results from both strict budgetary allocation and finite contract length. Privatization of maintenance procedures is broken down into three broad categories: routine, periodic, and emergency maintenance; each of these categories includes all items within right-of-way of the network. Routine maintenance procedures are performed over the contract cycle and according to performance standards. These procedures include pavement maintenance, re-grading road shoulders, replacing damaged furniture, and normal maintenance procedures such as grass cutting, cleaning, and repainting. Additionally, routine maintenance procedures include patrolling for network inspection. Periodic maintenance is a set of planned procedures based on roadway inspection and evaluation. These procedures are budgeted annually under two subheadings, pavement and non-pavement activities. Emergency maintenance procedures are those which address traffic flow under conditions of stress such as roadway blockage, flooding, or culvert collapse. Ahmad et al. concluded that the privatization of Malaysian roadways has several fundamental differences compared with its public counterpart. Essentially these differences place responsibility of roadway safety and ride on the roadway operator, based on available funds.

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**Black Ice Detection in Open-Graded Friction Courses** by Manuel Trevino, Terry Dossey, Yetkin Yildirim

New Generation Open-Graded Friction Course (NGOGFC), or Permeable Friction Course (PFC) pavements, have many potential benefits including good friction, lower noise, reduced hydroplaning, reduced splash and spray, and reduced nighttime glare in wet weather conditions. However, some states have experienced durability or maintenance problems with this pavement type. Most significantly, under winter conditions NGOGFC pavements have been known to freeze faster and longer than other pavements, as well as experience black ice. This study has developed a methodology to detect black ice formation on NGOGFC pavements by monitoring key factors such as temperature and moisture, with sensors embedded in pavement structure. Methodology was tested in laboratory experiments and implemented onsite in NGOGFC pavements in North Texas. Results of this study confirmed that this methodology for detecting ice formation on porous pavements is reliable. Laboratory tests paralleled field data, confirming that sensors are capable of identifying the heat of fusion temperature plateau effect key to detecting black ice formation. Future research efforts will incorporate remote real time pavement temperature monitoring and enable ice detection. With the addition of a Yagi antenna, this system will achieve remote sensing up to 22 miles- enabling these sensors to communicate with maintenance offices within this range. Additionally, wireless devices, namely point transceivers, will be installed at various sites. This will allow for real time monitoring of pavements and inform offices of the effectiveness of maintenance procedures. The significance of this study is not limited to NGOGFC sections but also to bridges; TxDOT will expand implementation of these procedures to freeze-prone structures in hope of decreasing winter-related accidents.

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**Estimation of Pavement Lifespan Using Stochastic Duration Models** by Jidong Yang

Pavement Management Systems (PMS) play a vital role in predicting pavement life and making informative maintenance/rehabilitation decisions. In this paper, Jidong Yang examines the possibility of using pavement condition surveys to predict pavement life. Yang contends that a stochastic duration model can be created using this dataset, deriving a pavement life-span model of in-service pavements from empirical data. In this research, Yang utilized Florida Pavement Condition Survey Database and Florida Traffic Information CD. Together these sources provided Yang with pavement condition data and annual traffic characteristics such as peak season factors and vehicle classification. With this information, Yang developed parametric duration models based on various hazard assumptions. He concluded that a loglogistic hazard function can better portray pavement failure mechanisms. Implications of this research suggest that reconstruction may be necessary after certain cycles of rehabilitation (as continuous rehabilitation does not take into account the augmented hazard for each cycle), greatly impacting cost-effectiveness.

Yang recommends coding pavement structural data into the PMS database when roads are reconstructed or rehabilitated, as these factors will enhance model performance.

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**Preservation Effects on the Performance of Bituminous on Aggregate Base Pavements in Minnesota** by Erland Lukanen

Minnesota Department of Transportation (MnDOT) evaluated the effects of pavement preservation activities on pavement performance. In this study, Erland Lukanen examined bituminous over aggregate base pavements (BAB) constructed between 1985 and 2005 in Minnesota. He divided this data set into two broad categories: pavements with no preservation and pavements which received preservation. He further divided the second subset, pavements with preservation, into those which have received either a mill and/or thin overlay and those which have not received either a mill or overlay. By analyzing a larger dataset, namely those which have or have not received pavement preservation, Luckanen was able to analyze overall performance trends and identify performance benefits of preservation activities. Additionally, he was able to implicate a relationship between preservation activities and modes of deterioration like ride, cracking, and rutting. This study concluded that preservation activities significantly increase the performance index ratings of pavements. Likewise, these activities decreased the rate of decline of the Ride Quality Index and lessened the growth of the three distress types which contribute to decline in Surface Ratings, namely transverse cracking, multiple cracking, and rutting. In general, pavements which received mill and thin overlay demonstrated the highest level of performance. Future research efforts will focus on the cost-effectiveness of pavement preservation, an increasingly important measure when petitioning for funding.

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**Summary and Assessment of Arizona Department of Transportation's Maintenance Cost-Effective Study** by David Peshkin

Beginning in 1995, Arizona's Department of Transportation (ADOT)'s SPR 371 Maintenance and Cost Effectiveness Study has identified maintenance and cost effectiveness treatments suitable for evaluation in Arizona. Since this time, Arizona DOT has tested alternatives, evaluating treatment performance and cost-effectiveness. In 1999, this ongoing project incorporated a study of bituminous pavement sections, breaking this study down into three phases: Phase I-wearing course treatment, Phase II-surface treatment, and Phase III-sealer rejuvenators. In this article, Peshkin evaluates Phase I and Phase II of this process.
Phase I-wearing course treatment evaluates the effectiveness of using premium plant produced hot mix, like an open-grade friction course, on high volume bituminous roadways. The goal of this project is to achieve a 12-15 year lifespan with minimal maintenance. Researchers have incorporated long-

term monitoring and accelerated testing through applying mill and overlay at different thicknesses. According to Peshkin, likely benefits of this treatment include delayed onset of environmental cracking, delayed fatigue cracking, and reduced rutting - as well as improved ride, weather resistance, and better surface texture. He calls for several actions to complete this phase - namely the acts of locating, evaluating, and rating key performance indicators. These measurements should be evaluated using manual and automated processes. Phase II refers to ADOT maintenance activities like chip seal and slurry seals - usually applied to lower volume roads. In this Phase, researchers aimed to evaluate the use of warranties, determine whether proprietary products can be specified in competitive low-bid processes, evaluate the effect of chip size on performance, compare binder types (polymer-modified vs. CRS-2), and evaluate the role of timing in treatment performance. Peshkin urges researchers to act quickly to make the most of available data. He claims that all test sections should be evaluated with special consideration of the "do nothing" sections. Unlike Phase I, Phase II treatments have a limited lifespan - and thus require acute attention during the experiment process. He anticipates benefits of these treatments to include improved surface characteristics and longer life between treatments. Peshkin asserts that next steps in this process should include clarifying data collections methods, determining collection frequency, and proposing methods of analysis and anticipated results. Overall, Peshkin suggests that researchers define "failure" and create an objective set of rules for removing sections from the study. He suggests that researchers create an evaluation schedule based on anticipated conditions. Peshkin hopes researchers will raise the profile of this experiment, updating stakeholders in progress, review of material and impact of findings. This should happen annually and touch upon key points like pavement life cycle, cost, and performance findings. These findings should be translated into implementation plans. Peshkin's review of this project alerts researchers to look beyond the creation of experiments and consider the necessity of accurate and thorough follow through. According to Peshkin, ADOT's SPR 371 Maintenance and Cost Effectiveness Study set out with lofty goals and has not capitalized on this opportunity to the fullest extent.

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**Long-Term Performance of Thin Bonded Concrete Overlay in Texas** by Dong-Ho Kim, Seong-Cheoi Choi, Yoon-Ho Cho, Moon Won

In 1986, Texas Department of Transportation (TxDOT) began a research initiative examining various bonded concrete overlays (BCO) on continuous reinforced concrete pavement (CRCP). This factorial experiment tested 4 inch BCO on existing 8 inch pavements on IH-610 in Houston, TX. Ten sites were selected on this roadway. Variables in the study included reinforcement type, either welded wire fabric or steel fibers, course aggregate type, including siliceous river gravel or limestone, and condition of existing CRCP. After 20 years, this study concluded that the 4 inch overlay improved the structural capacity of the pavement. This was demonstrated by testing deflection before and after overlay application with a reduction factor of one-third. The welded wire fabric proved to be better at reinforcing overlaid concrete than its counterpart, steel fibers, which did not prevent punchouts or spalling to the same degree. Additionally, the study indicated crushed limestone aggregate with welded wire fabric had the highest performance ratio. Overlays with limestone benefited from its low coefficient for thermal expansion and low elasticity. Overall, this variable exhibited no single distress over the 20 year study. Most significantly, this study highlighted a low correlation between shear bond strength at interface of old and new concrete and overall performance of pavement. This final conclusion may indicate that other variables play a role in BCO performance; however with only 10 testing sites, this result is inconclusive. Overall, implications from this study will be incorporated into TxDOT BCO design/materials/construction practices.

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**Ultrathin Bonded Wearing Course as a Pavement Preservation Treatment for Jointed Concrete Pavements** by Judith Corley-Lay, Jeffery Mastin

According to Judith Corley-Lay et al., ultrathin bonded wearing course (UTBWC) is an important pavement preservation technique. This technique, unlike thick overlays, is usually only 5/8th of an inch thick; in turn, this treatment minimizes the peripheral costs associated with thick overlays like adjustment of signs, guardrails, bridge clearance and shoulders, while adding years to the life of a pavement. In this study, Corley-Lay et al. examined the effect of UTBWC on jointed plain concrete in North Carolina. This research is significant for North Carolina, a state that constructed large amounts of concrete roadways in the 1960's and 1970's, due to the simultaneous "aging out" of large portions of this infrastructure. In this study, researchers selected five pavement sections which include both rural and urban roadways. The goal of this research was to determine the affects of UTBWC on the life extension of aging pavement in North Carolina. Researchers evaluated the effectiveness of this treatment by using pavement condition ratings, IRI, and in one case the impact of the treatment on noise reduction. Results of this study determined that UTBWC can extend pavement life by 6-10 years, a significant increase considering the pavement's age. Additionally, this treatment greatly affected the ride quality, as demonstrated by an 80 point improvement by the roughest roadway in this study. The effect of this treatment on reflective cracking also appeared positive, rendering this distress to be narrow and of low severity. Researchers suggest that future use of this treatment take into account the condition of the slab; slabs which are shattered or unstable should be reconstructed prior to UTBWC treatments. Additionally, roadways which exhibit large dips or otherwise need profile reshaping should have a leveling course applied prior to this treatment.

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**AASHTO-NTPEP Joint Sealant Field Evaluation Procedure** by James McGraw, Mike McGough, Eddie

Johnson

In 2003, Minnesota Department of Transportation (MnDOT) conducted the first Portland Cement Concrete joint sealant field evaluation for the AASHTO National Transportation Product Evaluation Program (NTPEP). Based on the Strategic Highway Research Program's (SHRP) Materials and Procedures for Repair of Joint Seals in Portland Cement Concrete Pavements-Manual of Practice, the NTPEP Joint Sealant Technical Committee developed a procedure for Mn/DOT to use both in laboratory and in field evaluations of joint sealants. The NTPEP procedure provides uniformity to field evaluation practices across participating state DOTs, as well as aids in site selection and pre-installation processes. Results of this new process seem to be positive. The data collected in the NTPEP process can be used to create Qualified Products Lists which establish guidelines for contractors for identifying approved products for construction and maintenance projects. Additionally, this format devises joint field evaluation management guidelines that can be used to train inexperienced personnel. This process has also revealed that current indicators for field performance, namely stone/debris retention SCN and water infiltration (cohesion/adhesion bond failure) held at equal weight, may not accurately predict field performance. This study suggests that greater emphasis on water infiltration may lead to increased accuracy for predicting field performance. Mn/DOT will further consider these findings and make formal suggestions to NTPEP Joint Sealant Committee.

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**Asphalt-Rubber Asphalt Concrete Friction Course Overlays as Pavement Preservation Strategy for Portland Cement Concrete Pavement** by Mark Belshe, Kamil Kaloush, Jay Golden, Michael Mamlouk, Patrick Phelan

Arizona Department of Transportation (ADOT) began its "Quiet Pavements" projects to curtail roadway noise impact on communities. This project has been remarkably successful, decreasing noise impacts in communities surrounding urban freeways up to 4 to 6 decibels; yet, the thin overlays of Asphalt Rubber-Asphaltic Concrete Friction Course (AR-ACFC) over existing Portland Cement Concrete Pavement (PCCP) also appear to extend the life of the pavements. This study examined and quantified the impact of AR-ACFC overlays on PCCP. It was hypothesized that these overlays mitigate thermal variances, a stress believed to cause 80% of PCCP damage. Study methods included temperature sensors to quantify thermal behavior of PCCP with and without AR-ACFC, use of Mechanistic-Empirical Pavement Design Guide to simulate pavement temperature changes, and calculations of thermally induced curling stresses to model pavement behavior. Results of this study concluded that AR-ACFC overlays have a significant impact on the thermal gradient of PCCP. This treatment can reduce thermal stresses by 25% during daytime high temperatures and 8% during nighttime lows. The only case where AR-ACFC has an adverse impact on PCCP thermal gradients is during nighttime lows with no traffic loads, such as shoulder areas with overlays. Further studies should be performed to obtain necessary information regarding the economic impact of AR-ACFC overlay treatments.

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**The Use of High Molecular Weight Methacrylate to Seal Bridge Deck Cracks: An Overview of Research** by Ashraf Rahim, D. Jansen, N. Abo-Shadi, J. Simek

Cracking is one of the most common distress types observed on concrete deck bridges. This distress can lead to structural deficiency, as untreated cracking allows moisture and sediment into the substructure, possibly causing accelerated corrosion of reinforced steel and deterioration of concrete. In this study, A. Rahim et al. examined the use of High Molecular Weight Methacrylate (HMWM) as a bridge sealant. This study looks to summarize previous research on the effectiveness of concrete bridge deck sealants, survey state agencies on their current use of HMWM, and develop guidelines for HMWM use. The conclusions of this study determined that all cracks must be sealed as soon as possible; otherwise, cracks may reach the chloride concentration threshold, resulting in corrosion and structural deficiency. With these concerns in mind, research demonstrated the importance of proper deck preparation and cleanliness required for successful sealant application - especially on older deck surfaces. HMWM sealant can be used to restore structural bond and flexural strength of pavements, so long as the pavements are not subjected to deicing chemicals, high chlorine environments. Additionally, cracks must be small; the survey indicated that HMWM is most often used to seal cracks less than 1.6 mm in diameter. This treatment should be applied every 4-5 years, or as needed, and application temperature should fall between the range 7°C (45°F) and 29°C (85°F) .

### Our Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost.

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THE UNIVERSITY OF TEXAS AT AUSTIN + COLLEGE OF ENGINEERING

TXDOT

# TEXAS PAVEMENT PRESERVATION CENTER

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**Summer 2007 / Issue 7**

**Inside This Issue:**



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## Issue Highlights

### Transportation Systems Preservation (TSP) Research & Implementation Roadmap Workshop

The FHWA has assembled a technical panel of experts in pavements and pavement and bridge preservation, which will ensure that the direction of the project is responsive to the diverse interests and needs of FHWA and state and local highway agencies. Two workshops on pavement preservation, held February 5 – 7 in Phoenix, AZ and February 26 – 28, 2007 in Orlando, FL, invited approximately 100 persons knowledgeable in pavements and pavement preservation, representing highway agencies, FHWA, TRB, industry, and academia to discuss, evaluate, and rank potential research problem statements that would compromise the Pavement Preservation Roadmap. Workshop sponsors included FHWA with AASHTO Highway Subcommittee on Maintenance, $FP^2$, TRB Committee on Bridge Management, and ESCINC. This issue summarizes the TSP Workshop presentations.

### Mark Your Calendar: 2007 Pavement Preservation Seminar

The 2007 Pavement Preservation Seminar will be held October 8-9 at the Austin Convention Center in conjunction with the 24th Annual Association of General Contractors of Texas Trade & Equipment Show. Sponsors for the Seminar are the Asphalt Emulsion Manufacturers Association (AEMA), the Associated General Contractors of Texas (AGC), the Foundation for Pavement Preservation ($FP^2$), the Texas Pavement Preservation Center (TPPC), and the UT Center for Lifelong Engineering Education (CLEE).
For more information, visit
http://www.utexas.edu/research/tppc/conf/pps/index.html

**Asset Management and Preservation** by John O'Doherty and Larry Galehouse

Transportation agencies have traditionally focused on physical road conditions, rather than on economics and cost-effectiveness. As road agencies begin the transition to proper asset management, they are discovering the difficulties involved with adapting private enterprise models to the public sector.

Agency officials face difficult budgetary constraints and, therefore, often make the safe political move of fixing the worst facilities until funds run out. Typically, officials have a tendency to concentrate on the present and deal with their networks at the project level. Modern management theory shows that highly complex operations, such as highway systems, can be successfully managed at the network level by using a horizon of multiple time periods. O'Doherty and Galehouse present two project-level management dilemmas that agencies now face: when to undertake physical improvements, based on physical or engineering criteria, and what thresholds to use, based on public views of the acceptable level of service. In other words, what exactly constitutes a good road?

Challenges exist at both the highway project and network levels. A major obstacle involves convincing agency management that many existing management systems, along with other management tools, have strong advantages and should be utilized. Also, agencies must ensure that the right data needed to conduct engineering and economic analyses is collected accurately. Fortunately, these two challenges can be solved without any further research. However, economic benefits and cost-effectiveness of individual preservation techniques need to be further assessed. With many factors affecting these figures, such as materials, design, workmanship, traffic, and climate, road agencies need to collect adequate data for use with modern Pavement Management Systems (PMS's).

According to O'Doherty and Galehouse, more research is needed in the area of Remaining Service Life (RSL) and other asset condition indicators. Accuracy in the calculation of these indicators is imperative; decisions involving allocation of vast resources will depend heavily on accurate research. It is also necessary to have the ability to link the asset physical condition to economic replacement thresholds and cost-effectiveness levels. Future research work could attempt to establish multi-regional baselines through economic analysis that will assist agencies in their asset management programs. Research in the area of budget allocation, such as investigating adjustments that encourage preservation, would be helpful, as well.

**Design of Pavement Preservation Activities/Projects** by Dr. R Gary Hicks, P.E. and Dr. Shakir Shatnawi, P.E.

Project design considerations constitute an essential element of pavement preservation programs. Placing the right treatment on the right road at the right time is crucial. For instance, pavement preservation should be performed only on pavements in good condition or with minor distress. Guidelines such as this must be adhered to for a program to function correctly.

According to Hicks and Shatnawi, it is necessary to have a selection process for choosing the appropriate treatment methods for any given project. This selection process must consist of the following steps: the assessment of existing roadway conditions, such as surface distress, traffic issues, and drainage and climatic conditions, the determination of feasible options by addressing functional issues, such as the surface condition of the pavement, and the analysis and comparison of every feasible option. The analysis of possible treatments should be based on the predicted life extension of the existing pavement resulting from the PP treatment, along with the results of LCCA or other economic evaluation tools. Road agencies need to conduct research and gather accurate data on determining optimal timing for PP treatments.

Although the work reported in NCHRP Report 523 provided a framework for optimal timing, this framework must now be field evaluated.

The design element issues of pavement preservation must be addressed before PP can advance throughout the industry. There are a variety of issues involved here, such as the need for road agencies to have a process for the selection of proper PP strategies for all pavement types that includes economic analyses of each feasible strategy. In order to resolve some of the PP design element issues, certain measures need to be taken. Better documentation on costs benefits and improvements, without the usual reliance on anecdotal information, would be helpful, for instance. Other vital issues include the optimal timing of treatments, the most effective number of treatment applications, and the need for valid justification for delaying pavement rehabilitation, reconstruction, and replacement.

Yet, the most important issue remains whether PP treatments are cost-effective compared to pavement rehabilitation. Further documentation of expected life extension from the application of preservation treatments is necessary in order to show whether PP programs are beneficial overall. For instance, the reasons for the variable performance of treatments applied must be explained. In addition, different analysis periods (for economic analysis) may be needed in order to study the difference in cost between preservation and rehabilitation programs.

Future research needs and topics for potential research projects related to this topic could include determining which pavement attributes would best assist agencies in the selection of PP activities, determining threshold limits or trigger values, or integrating preventive maintenance and pavement management.

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**Materials for Pavement Preservation Activities/Projects** by John B. Johnston and Larry Galehouse

In this study, Johnston and Galehouse formulate a framework for the development of research problem statements that accurately address the effect of materials selection on the performance of preventive maintenance treatments. The quality of the materials used significantly impacts the life span and long-term performance of the construction project. Pavement preservation treatments are usually relatively thin but must withstand large amounts of stress, such as adverse environmental conditions and heavy traffic.
Recent reviews of the literature show that little research has been conducted on materials selection, mix design, and materials testing. Most of the available research has centered on evaluating the performance of crack and joint sealing and filling products, and to a lesser extent, the investigation of improved mix design methods. Nationally conducted surveys have determined that, among pavement practitioners, a high level of interest exists about the study of crack and joint sealant material performance and the methods used to select sealant products.

The on-going reviews of traffic agencies have revealed a tendency towards using local aggregate sources. Those in charge of materials selection generally focus on the low cost and high availability of such products, rather than their quality and long-term performance capabilities. This often occurs because many practitioners simply do not fully understand the impact of aggregate quality on treatment life and performance. Because they are not supplied the proper quantitative data needed to judge whether using local materials or importing high-quality aggregate would be the most cost-effective, most practitioners choose the less costly of the two by default. Furthermore, many decision-makers are unsure how to judge if a material is sufficient or substandard for a given treatment. Without these necessary tools to justify spending more on imported, higher quality aggregate, selecting cheaper and inferior materials seems to be the only sensible choice. This problem is further heightened by the general lack of availability of high-quality aggregate in some areas.

Practitioners must develop a better understanding of the cost-benefits associated with selecting one material component over another, especially when screening and selecting aggregate sources. Due to insufficient data, informed decisions about when to use local or imported aggregate materials are rare. Practitioners need to have an understanding of the material parameters that impact performance and utilize reliable methods of measuring those parameters, in order to make proper aggregate selection choices.

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**Concrete Pavement Preservation** by John Roberts and Larry A. Scofield, P.E.

Pavement preservation (PP) goals can be divided into three main desired outcomes: pavement life extension, improved safety, and consumer satisfaction. As defined by FHWA, PP employs a long-term strategy aimed at enhancing pavement performance by using cost-effective practices that extend pavement life, improve safety, and meet consumer demand. When defining pavement extension, the FHWA differentiates between treatment life extension and pavement life extension. PP life estimates are commonly referred to in terms of treatment life, such as 3-5 years. If the treatment does not extend the life of the existing pavement, however, it is no longer cost-effective and its service life is, therefore, insignificant. This concept is crucial, especially when tight budgets make the worst-first strategy attractive. Ideas about safety and customer satisfaction must also be reexamined in order to enact successful pavement preservation.

In emphasizing the preservation concept, PP programs often claim that a high initial cost can lower costs down the road. This theory is linked to the belief that investments made during the preservation process are much more cost-effective than those made during the resurfacing or reconstruction process. However, this is an oversimplification of matters, which can often lead to decisions based on hearsay rather than engineering data.

Concrete pavement has previously been utilized in predominately urban areas with high traffic volumes. The term concrete pavement preservation ($CP^2$) describes a series of engineered techniques developed over the past 40 years to manage the rate of pavement deterioration in concrete streets, highways, and airports. $CP^2$ is a non-overlay option used to repair concrete pavement without changing its grade. This preventive procedure restores pavement to a condition similar to or better than the original and reduces the need for costly repairs later on.

$CP^2$ comes with a variety of benefits. Firstly, it is less expensive and more effective than overlay treatment techniques because it actually prevents further pavement deterioration by addressing the causes of the distress and not just the symptoms, as an overlay would. Not only is this type of treatment less costly than others, it also lasts longer and causes less traffic disruption. Because it does not affect the grade of the pavement, $CP^2$ is an unusually quick treatment. Roadway features like gutters and curbs do not need to be adjusted, and it can be used to repair only the areas that need improvement, both of which speed up the entire construction process considerably. Finally, $CP^2$ can even be used to repair concrete that was previously overlaid with asphalt.

Because of concrete pavement's reputation for having a long service life, when the budget is tight, concrete pavement preservation is typically overlooked. Agencies often fix the worst pavements first during times of financial stress. Since concrete pavements can sometimes last longer than their design lives, $CP^2$ is often ignored, and preservation funds are expended elsewhere. This will commonly lead to many concrete pavements experiencing little or no preservation.

For PP to be truly effective it is not sufficient to merely analyze the differences in performance levels and utilize $CP^2$ to mitigate their impact; the features that cause these differences must be identified at the beginning of the design process. For example, one of the most debated design considerations is whether or not to seal joints. Even though joint sealing has been utilized for almost sixty years, experts continue to disagree over the benefits of this practice. Agencies often do not have sufficient data to determine an activity to be necessary that represents 3-5% of the initial cost and is an expensive $CP^2$ treatment.

The potential for research projects on $CP^2$ abounds. Researchers could conduct studies that establish actual concrete performance curves and $CP^2$ strategy effectiveness, for example. Determining the most effective intervention cycles for $CP^2$ strategies based on actual Life Cycle Cost (LCC) principles would also be extremely useful to the development of this type of treatment. Data that would improve network level investment decisions by determining optimum design life strategy selection and $CP^2$ intervention interval selection could improve matters greatly, as well.

**Quality Construction of Pavement Preservation Activities/Projects** by Dean M. Testa, P.E., Dennis C. Jackson, and Colin Franco

Testa et al.'s paper emphasizes the importance of maintenance projects. When these projects are being administered, constructed, and inspected, they are often referred to as “just maintenance projects.” While maintenance operations are expected to benefit existing pavement, the general consensus is that such projects are relatively unimportant. However, addressing these projects as “fill in work” or ”just maintenance,” leads to an incorrect representation of their value, as “simple” maintenance operations are essential to adequate pavement conditions.

Agencies must examine their current practices and improve any areas that are inhibiting good PP practices. Old ways of thinking about maintenance must be thrown out, and PP activities must be considered at least as vital to an agency’s success as rehabilitation. Adequate funding for preservation must be set aside. Agencies should work with contractors in order to streamline the process. All possible outcomes of any change, such as requiring contracts to have warranties, should be considered.

Agencies must also try to improve their public image through educating roadway users about PP. Public highway surveys have revealed that motorists do not want to be inconvenienced by construction or reconstruction projects. In addition, motorists demand that projects be finished more quickly and have longer-lasting results. The traveling public needs to realize that pavement does not last forever and that they cannot always visually see potential surface distress failure. Agencies must educate consumers so they can fully understand why agencies work on good roads, while other roads, some in failing condition, are ignored. Educating the general public would allow agencies and contractors to focus on producing quality work rather than taking time out to handle complaints. Also, providing users with real-time traffic information can also be helpful in alleviating the tension between customer wants and necessary inconveniences.

Contractors and agencies must work together to improve the entire system. Contractors can take steps such as utilizing trained crews and performing their own quality control activities.

Testa et al. recommend a few potential studies related to this topic. Some research could be conducted to develop and/or certify ‘specialized’ contractors or individual crew members for PP projects. Further research should investigate the benefits of agencies and private contractors jointly developing new products and processes, how warranties can be utilized to improve quality of construction and effective pavement life, methods of communicating to the traveling public the reasons why agencies work on good roads, while others are allowed to deteriorate, and effective methods for getting real-time traffic information to the highway user when preventative maintenance is currently underway.

## **Methods of Maintenance Contracting** by David Peshkin, P.E. and James Carney, P.E.

When an agency chooses to hire a private firm to perform a pavement preservation activity, a maintenance contract is used. Usually the agency will select one of the four main types of maintenance contracts described in this study. The maintenance contracts discussed by Peshkin and Carney are method-based, performance-related, and performance-based contracts, along with contracts that include warranties.

Method-based contracts are the most common type of contract used for pavement maintenance work performed by a private contractor. In a method-based contract, the agency specifies how the work is to be carried out in detail, and the contractor must adhere to these specifications to receive payment. Although method-based contracts may be considered “safe,” they place most of the responsibility for the success of the performance of the treatment with the owner agency, rather than with the contractor, and inhibit innovative techniques and materials.

Performance-related contracts use measures of the final product’s properties to judge the contractor’s work. The agency specifies certain properties that the finished pavement should exhibit, and if all of the specifications are met, the job is considered satisfactory. This type of contract allows the contractor to use more innovation and invention than the method-based contract but requires the agency to have a thorough understanding of the performance measures specified in the contract.

Performance-based contracts are similar to performance-related contracts, though they give even more control to the contractor. They are not currently used for pavement preservation projects but for other maintenance jobs. With performance-based contracts, the owner agency can be less specific as to the required results but also must be willing to accept any method and materials the contractor chooses to use to meet the project requirements.

Contracts that include warranties focus on the long-term performance of a pavement treatment. Agencies are attracted to warranty contracts because payment can be deferred for a specified period of time in order to judge the maintenance construction's durability. However, warranty contracts come with several problems, including higher cost and a need for more careful project selection.

Agencies must acquire the data necessary to determine when each type of contract should be used. Currently, several studies, such as the Arizona DOT's, are underway to produce guidelines for contract selection.

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**Pavement Preservation Treatment Performance** by Dr. Yetkin Yildirim, P.E. and Joe W. Button, P.E.

For a pavement preservation program, pavement performance is a key element. Agencies must have an effective method of evaluating pavement performance. Understanding how preventive maintenance treatments affect pavement performance is especially essential for PP. Currently, this relationship is unclear, as thorough research on the subject has not been conducted.

Yildirim and Button discuss the concept of pavement performance, factors that affect performance, the development of performance specifications, the importance of training and policy for improving pavement performance, and the issues involved in applying performance measures in pavement preservation programs. Finally, future projects related to pavement performance are suggested.

Performance can be defined as the durability and longevity of a pavement or the amount of maintenance required to maintain an acceptable level of service during the design life of a pavement. Performance is mainly determined by which treatments, materials, and treatment strategies are used and when. Agencies must rethink the way in which performance is evaluated, as the improvement of pavement performance should be a main concern for every PP program. By developing performance specifications for PP treatments and addressing the design and construction of preventive maintenance treatments in training, agencies could vastly improve their PP programs.

Future studies on this topic will broaden the existing knowledge of PP and help advance effective preservation strategies. Yildirim and Button suggest that researchers investigate the effects of PP treatments on pavement performance, study the impact of treatment on functional performance, determine the optimal timing for treatments, define treatment failure, examine construction and performance of PP in the field, research performance specifications and materials, and investigate possible training tools.

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**Surface Characteristics** by Dr. Mark Snyder, P.E. and Larry Scofield, P.E.

Pavement surface texture affects the interaction between tires and the pavement in many ways, such as friction during wet-weather, amount of splash and spray that occurs when the pavement is wet, noise, rolling resistance, and tire wear. Surface texture is a composite of different combinations of texture depth, which is also known as amplitude, and feature length, with each combination affecting tire-surface interaction differently. This paper focuses on the four categories of pavement surface characteristics proposed by the Permanent International Association of Road Congresses (PIARC) in 1987: microtexture, macrotexture, megatexture, and unevenness, or roughness. Each category is described, and the effect of each on tire-pavement interaction is detailed.

Microtexture is usually all that is needed to provide adequate friction for dry roads with normal vehicle speeds and for wet pavements if the vehicle speeds are less than 50 mph. Microtexture generally does not contribute to pavement noise or splash and spray. Macrotexture allows for good friction levels on wet weather roads, even for roads with higher-speed traffic. This surface characteristic has the highest impact on pavement noise and splash and spray. Megatexture is typically caused by poor construction practices, surface deterioration, or local settlements. It can produce in-vehicle and external noise and adversely affects pavement ride quality. Megatexture can even cause premature wear of vehicle suspension parts. Finally, unevenness impacts ride quality, vehicle dynamics, and surface drainage, though it has no significant effect on pavement noise.

In order to study pavement surface texture and the influence it has on tire-pavement interaction, the surface texture, roadway friction, roadway noise, and roadway profile must all be measured accurately. Snyder and Scofield describe the ways in which each measurement is taken and the current practices that are used the most by state road agencies.

Many potential research projects related to this topic exist, including developing procedures that allow the prediction of noise and friction levels from texture measurements, developing a better noise annoyance metric, and studying high-speed 3-D texture measurement equipment.

**A Literature Review of Recent Pavement Preservation Research: Preservation Research Roadmap** prepared for The Foundation for Pavement Preservation by The National Center for Pavement Preservation

This study is a literature review intended to establish general topic areas for future research and development. The literature review is the first phase of the Transportation Preservation Strategic Research and Development Road Map project sponsored by the FHWA. By analyzing a number of typical recent research endeavors, the areas in which research is lacking may be identified.

The authors classified each pavement preservation-related research project according to one or more of eight categories: treatment performance, treatment timing, treatment selection, life-extending benefits, cost effectiveness, construction techniques/best practices, materials selection, and specifications and warranties. Most prior research focused on treatment performance; the second most researched topic was treatment selection.

The benefits and effectiveness of warranty programs has not been thoroughly assessed, and little has been done to measure the effectiveness of programs' current specifications.

Materials selection and mix design have not been researched sufficiently, as they are more often addressed in qualitative rather than quantitative terms. Materials selection has proven to be a very difficult topic to research.

Some topics, like best practices, have been written about extensively in literature reviews but not in literature based on scientific research. That is, most of the research does not use experimentation to justify the conclusions but rather refers to other publications. Much of the literature on pavement preservation draws from experience and not from quantitative findings.

Finally, the review found that most of the existing literature is concerned with flexible pavements. Research on rigid pavement preservation is scant.

Where sufficient information on a particular topic is lacking, there lies a need for research. This study has identified seven topics that need to be covered in future investigations: materials, design, construction, treatment performance, contracting methods, asset management, and policies, training, and public relations. Each of these research topics is discussed fully, divided into further, smaller research topics, and weighted, based on the findings of Peshkin and Hoerner's 2005 study. The literature review provides a comprehensive guide to identifying research needs.

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COCKRELL SCHOOL OF ENGINEERING
TxDOT

# TEXAS PAVEMENT PRESERVATION CENTER Newsletter

ISSUE 8 / FALL 2007

**Fall 2007 / Issue 8**

**Inside This Issue:**

**Proceedings from the 2007 Pavement Preservation Seminar**





**Our Mission**

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

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**Issue Highlights**

## The 2007 Pavement Preservation Seminar

The 2007 Pavement Preservation Seminar was held Monday and Tuesday, October 8-9 at the Austin Convention Center in conjunction with the 24th Annual Association of General Contractors of Texas Trade and Equipment Show. The seminar was a great success, and the Texas Pavement Preservation Center would like to thank all those who participated in this effort to share knowledge and advance the field of pavement preservation. Special gratitude goes out to the sponsors of the event, namely the Asphalt Emulsion Manufacturers Association (AEMA), the Associated General Contractors of Texas (AGCTX), The Foundation for Pavement Preservation (FP2), the Texas Pavement Preservation Center (TPPC), and the University of Texas Center for Lifelong Engineering Education (CLEE). To further the educational benefits of the seminar, all of the presentations described in this issue are available in video form on our website at www.utexas.edu/research/tppc/conf.

## Mark Your Calendar: TRB 87th Annual Meeting

The Transportation Research Board (TRB) held its 87th Annual Meeting January 13-17, 2008 in Washington, D.C. The TRB Annual Meeting program consisted of over 3,000 presentations in 600 sessions and attracted over 10,000 transportation professionals from around the world. All attendees received the TRB Annual Meeting Compendium of Papers DVD, which contains more than 1,800 technical papers. For more information, please visit the TRB website at www.trb.org/meeting.

## Pavement Preservation Journal

The first issue of the Foundation for Pavement Preservation's Pavement Preservation Journal was published in August 2007. The quarterly publication includes case study papers describing experiences of industry personnel, contractors, and academic researchers and technical papers, consisting of new research developments. For more information, please visit the Foundation for Pavement Preservation's website at www.fp2.org.

*The following reports on the presentations made at the 2007 Pavement Preservation Seminar. Some of the statements are opinions of the contributors and not necessarily those of the TPPC or TxDOT.*

### **Chip Seals** presented by Bill O'Leary

Bill O'Leary's presentation on chip sealing was full of practical information about this common surface treatment. O'Leary discussed many aspects of chip sealing, including the benefits of chip seals, road conditions that can and cannot be treated by chip seals, factors that affect the quality of the treatment, necessary pavement preparation prior to application, materials, application methods, and reasons chip seals often fail.

O'Leary indicated that chip seals are useful for many reasons. They extend pavement life, seal the road against air and water intrusion, improve skid resistance, delineate the main road and the shoulder, and can also be used as an interlayer to enhance the bond between an overlay and the existing pavement. However, chip seals cannot increase the strength of a pavement nor fix one that has failed. Therefore, chip seals should only be placed on roads with minimal structural distress. The condition of the existing roadway is a main factor affecting the quality of the treatment.

When placing a chip seal, important considerations include the condition of the current roadway, which materials to use, whether to place a fog seal over the chip seal, the knowledge and expertise of the inspectors and supervisors, and the rate of application. Such decisions should be made carefully, as treatment failure can occur for a variety of reasons: too little binder, too much aggregate, poor traffic control, weather, or too stiff binder. Bill O'Leary's presentation would certainly assist anyone trying to lay a successful chip seal surface treatment.

### **Chip Sealing over Fabric in Borrego Springs** presented by Lita Davis

In the northeast corner of San Diego County lies Borrego Springs, CA. With a desert climate in the lower 500 feet of elevation, pavements here are particularly prone to cracking. In the evening, the temperature drops to about 30°F, but during the day the desert sun beats down on the roadways of Borrego Springs. This frequent change in temperature causes expansion and contraction, making oxidation and cracking extremely common. The labor required to seal all the cracks in a typical road segment was far too expensive, and in 1987, the local highway agency decided to test six different products on one roadway to see if the cracking problem could be alleviated. One of the products tested was a chip seal over fabric. The chip seal over fabric test segment has not required crack sealing since 1987.

The effectiveness of this treatment has contributed significantly to its relatively low annual cost. In a 30 year lifetime cost analysis based on 396,217 square meters or 465,460 square yards, chip seal over fabric treatments were found to cost less than both a crack seal with a conventional chip seal and a rubberized chip seal. The crack sealing with a conventional chip seal was found to cost $239,939 annually, the rubberized chip seal costs $166,886 per year, and the chip seal over fabric should cost only $107,137 a year. Although chip sealing over fabric is initially more expensive than the other two treatments, the long-term savings can make it well worth the initial cost.

### **Performance-Based Specifications on Chip Seal Projects** presented by Lita Davis

Lita Davis began by outlining three points she hoped to help the audience understand: being "in spec" does not guarantee a good chip seal, the difference between method and performance-based specifications, and how the roles of both the agency and the contractor change with performance-based specifications. To this end, Davis discussed common problems that agencies and contractors have when they do not use performance-based specifications. Often, an agency will expect the contractor to make repairs if any problems develop in the treatment. However, contractors usually refuse because the agency was in control of nearly all aspects of the construction of the chip seal, not the contractor. Agencies must learn to either relinquish control or take full responsibility when a treatment is unsuccessful.

Many agencies currently use method specifications (also called prescriptive specifications) when drawing up a work contract. Method specifications entail that the agency specifies the requirements for materials, dimensions, tolerances, work force, and construction methodology. Method specifications may or may not require a guarantee for the quality of the work from the contractor. Even if a guarantee is required, it will usually only cover faulty materials and/or faulty workmanship and not the performance of the end product.

A performance specification, which is an umbrella term that can describe either performance-based specifications or warranties, actually defines the performance characteristics of the finished product before construction begins. Performance is usually linked to materials, construction equipment and methodology, and any other factor that lies within the contractor's control.

Davis describes switching from method- to performance-based specifications as a "win-win" situation for the agency and contractor. In a construction situation, the wants of the agency include a good chip seal and the ability to hold the contractor responsible for the performance of the treatment. The contractor's goals are to have control over the materials ordered and the construction operations and to be responsible for the end product. Therefore, performance-based specs appeal to both parties.

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**Selection and Characterization of HMA Mixes for Thin Asphalt Overlays: A Theoretical Analysis** presented by Lubinda F. Walubita, PhD

Dr. Lubinda Walubita's presentation on thin asphalt overlays shed light on many aspects of overlay mix and design, and described the treatment in general, including its main uses, advantages, and disadvantages. Thin HMA overlays are known to be excellent non-structural overlays that are commonly used for preventive maintenance, pavement preservation, and minor rehabilitation projects. They can be used to treat minor surface damage, such as raveling or bleeding, but only on structurally sound pavement. When used correctly, thin HMA overlays can enhance the appearance of a roadway, improve its functional characteristics, improve impermeability characteristics, and enhance pavement performance.

Using a thin HMA overlay is a cost-effective method of preserving and maintaining existing pavements, although overlays have disadvantages as well. According to Walubita, the main problem with thin HMA overlays lies in the limited scope of specifications and standards for the treatment. Most often, these specs and standards are agency-specific or proprietary in nature. Because of this, there are almost no widely accepted thin HMA overlay specifications for general applications or to use as reference guidelines. The present study was geared toward reviewing the general criteria for the selection and design of thin HMA overlay mixes and documenting the material characterization and mix design procedures in order to achieve satisfactory in-service performance.

The methodology used in this study began with an examination of the preferred materials used in thin HMA overlays. The most popular binders in the United States are PG 76-22 (SBS), which are polymer modified binders. Stiff binders are usually desired because they are less sensitive to temperature, rutting, and oxidative aging. Aggregates should be high quality gap-graded fine aggregates with good skid resistance characteristics, low soundness values, and durability. Other additives involved in thin HMA overlays are lime and silicon dioxide for extra skid resistance.

The proprietary mixes for thin HMA overlays commonly used today include Marshall, Superpave, Novachip, PAVEtex, and balanced mix-design. This presentation suggests a new balanced mix-design approach that has shown promising results but still requires field validation. Even with improved mix design, the satisfactory performance of a thin HMA overlay is not ensured. These treatments depend on good construction practices just as much as on the materials used. The condition of the existing road is also vital to the success of the treatment. A thin HMA overlay is sure to fail if placed on a pavement with serious structural distress or if placed improperly during construction, regardless of the quality of the materials and design employed.

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**Binder Selection** presented by Darlene Goehl, P.E.

Binder selection is critical when planning a microsurfacing, thin overlay, or other surface treatment project. Darlene Goehl's presentation aimed to clarify which binder should be selected for which type of project, based on her experiences in the Bryan District in Texas. For microsurfacing, Goehl recommends using a CSS-1P binder. HMA overlays can be of two varieties: spot level-up treatment and thin overlay. A spot level-up should be designed for workability and generally uses a PG 64-22 binder. For an overlay, the design should be based on the existing pavement. PG 64-22, PG 70-22, or PG 76-22 binders are typically used for overlays.

Some criteria that should be considered when selecting a binder include the purpose of the seal being placed, the condition of the existing pavement, the time of year, the weather, and traffic levels. Typical surface treatment binders are asphalt, emulsions, and cutback. Each different type has different temperatures and seasons in which it can be placed. Further, asphalt concrete requires the aggregate to be precoated to minimize dust accumulation and improve the adhesion of the aggregate to the seal coat binder. When using an emulsion or cutback, however, the aggregate should not be coated, as the precoating inhibits the binder's chemical break, absorption, and adhesion to the rock.

When selecting a binder involves seasonal decisions, it is important to note that both cool and hot weather binders are available. Hot weather binders should be placed when the temperature is 70°F and rising, whereas cool weather binders may be applied when the air is between 40° and 70°F. If traffic interruption is a concern, some binders should be considered over others. Asphalt cement (AC) stiffens and binds the aggregate more quickly than is possible with an asphalt emulsion, and therefore will allow traffic to travel over it sooner. Rain and humidity can become problematic when an asphalt emulsion is used, as humidity can slow the curing time and rain necessitates keeping traffic off the road until it dries. Many other factors can affect the setting or breaking rate of an emulsion, such as the porosity and moisture content of the aggregate, the temperature, mechanical forces, cleanliness of the aggregate, and the type and amount of emulsifying agent used.

The last criterion to consider when selecting a binder is cost. Goehl included a chart in her presentation that depicted a cost comparison between asphalt cement with precoated aggregate and emulsion with uncoated aggregate for several different levels of average daily traffic. The costs for this chart were based on the average bid prices in the Bryan District. Goehl found asphalt cement to be the more economical of the two for each traffic level studied.

**Chip Seal Asphalt Binders** presented by Bill O'Leary

Asphalt binders are traditionally used in three different ways: hot, which creates asphalt cement, cut-back, which is a binder diluted with solvent, and emulsified asphalt. Many different chip seal binder liquids exist today, some created with latex, others with recycled tire rubber. One consideration remains as important to the industry as ever: the price of asphalt continues to dictate which projects agencies can complete.

Asphalt price is affected by a variety of factors, such as the availability and price of crude oil, coker feedstock, and residual fuel, the market and road building budget, the weather or season, and the competition. Usually, a quick and easy way to find the price of asphalt is to multiply the crude oil price per barrel by 5.6. The solution is usually close to the price of asphalt per ton. However, this year, because the market and demand for asphalt is down, asphalt prices are almost a dollar less per ton than they should be considering the cost of crude oil. If crude oil prices continue to rise, asphalt prices are certain to catch up in the near future.

**History and Future of Pavement Preservation** presented by James Sorenson, P.E.

According to James Sorenson, out of the five most developed countries in the world, the U.S. has the least amount of money going into pavement preservation. Even though funding has not reached an appropriate level, people are starting to realize that pavement preservation works more efficiently than a reactive or periodic approach. Some programs, like the TxDOT seal program, still utilize a systematic approach, though many in the industry have fully adopted the "right treatment, right road, right time" creed. Those in the business must make intelligent choices; sometimes a fog seal is enough, other times a cape seal or something long-lasting is the right fit. Choices need to be made based on the best course of action.

Pavement preservation is vital to maintaining the road system. Everyone who thinks of pavement preservation should bear in mind the upkeep required on a house. If a house needs a coat of paint but is neglected, soon the siding may become damaged and need to be replaced. Like a house, pavement needs constant minor and relatively inexpensive upkeep to prevent more costly repairs later on.

The really appealing aspect of pavement preservation is the rate of return that can be had in comparison to new construction and rehabilitation projects. The rate of return for new construction is usually about 1.6 or 1.8 to 1 and 1.2 or 1.4 to 1 for rehabilitation projects. Pavement preservation activities, however, have a return rate somewhere in between 6 and 10 to 1. The return involved makes pavement preservation the right choice when agency budgets are constricted. Sorenson believes agencies should require a certain percentage of all roads to be covered with some type of treatment and improved in some way each year.

One obstacle for the advancement of pavement preservation has been a lack of experience. In 1997, a regulation was passed that required construction workforces to be properly trained and qualified. Since then, 43 states and five geographic regions have composed organizations to create PP-related training courses. There are, however, only a few centers based on pavement preservation, including the Texas Pavement Preservation Center. To supplement this are sources online from which people involved in the industry can receive certification. The National Center for Pavement Preservation has several online training courses, for example, at www.pavementpreservation.org.

**Aggregate Issues** presented by Caroline Hererra, P.E. and Pat Wootton

Caroline Hererra's presentation focused on aggregate as it pertains to seal coats. Hererra finds seal coats to be a great preservation strategy, as they improve surface friction, provide a moisture barrier, extend a pavement's lifespan by seven to ten years, and are relatively inexpensive. In a seal coat, the aggregate is almost totally exposed, which means that it must bear the brunt of both adverse weather conditions and traffic loading. Furthermore, this aggregate is usually only one rock thick. Thus, aggregate in seal coats must be very high in quality and carefully designed.

Good surface friction is vital to the safety of our roadways. The only way to ensure proper skid resistance is through an effective aggregate design that takes both micro and macro texture into consideration. Macro texture depends on the voids between the aggregate stones and the way the stones fit together. Macro texture is responsible for keeping water off the surface of the road. Micro texture is the texture of the individual stones themselves. An obstacle to achieving good micro texture is the relatively low durability of stones with high amounts of micro texture; smooth, dense stones are generally more durable.

Herrera's presentation then moved to the classification of aggregate by quality. In 1999, the WWARP classified aggregate frictional properties into three different categories: SAC A, B, or C. The boundaries for each category were based on existing skid data. This method was somewhat problematic, however, as prior to 1999, skid testing was not required. Therefore, there was little data to work with. From 1999 to 2006, skid data has been collected on 50% of the interstate every other year. This real-life performance data is then used to judge the effectiveness of the classification system.

Currently, agencies are looking for new ways to measure and test aggregate properties. Some of the latest developments include the aggregate imaging system, aggregate crushing value (ACV), and aggregate impact value (AIV). Tests like the Micro-Deval can also measure the friction, toughness, durability, and abrasion resistance of aggregate. Through empirical testing, agencies can know with certainty the quality of the aggregate they are receiving and the performance that can be expected from every classification of aggregate.

Next, Pat Wootton of Vulcan Construction Materials took the lectern to discuss aggregate issues from a producer's point of view. In response to an attendee's question, Wootton explained the relationship that his company has to recycled concrete and base material. He said that in Houston, these materials are being used extensively. Although his company would rather sell virgin aggregate, recycled material creates a profit, too. Therefore, the company sells a lot of both kinds of aggregate.

Wootton was then asked if his company is doing anything to keep aggregate costs low. He answered in the affirmative: the company is putting load capacity monitors on belts and installing automatic shut-offs to ensure proper flow during materials production. Hopefully, this will decrease costs in the future.

Finally, Wootton explained the material testing that takes place at aggregate production companies. Currently, work is being done to develop sturdier, less sensitive testing devices that can be used in quarries to study stone texture and other properties. At this point, TxDOT does not require producers to use any particular type of test, but that may change in the future. TxDOT has, however, put out a soils and base testing certification program, which may improve testing practices.

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**Microsurfacing and Slurry Seals** presented by Paul Montgomery, P.E., Barry Dunn, and Pierre Peltier

The panel on microsurfacing and slurry seals began with Paul Montgomery's discussion of the general uses and guidelines for microsurfacing treatments. Microsurfacing can effectively fill ruts up to 1 inch, improve skid values, cover flushed or bleeding pavement, improve wet-weather characteristics, and reduce noise. It cannot add structure to a road, fill deep ruts, stop reflective cracking, or repair a bad ride. Microsurfacing should only be used on roads with good structural characteristics. To test for this, a Falling Weight Deflectometer can be used; the result should be less than 30 mils or microsurfacing should not be considered. Furthermore, the existing highway should have a good seal prior to application.

Microsurfacing should only be applied when the temperature is 50°F and rising. The surface should be clean and free of excessive scratches, marks, and tears but should still have some macro texture for friction. Microsurfacing costs about twice as much as a seal coat and about half as much as a thin overlay. An average treatment will last five years, but if sealed again, could further extend pavement life by six or seven years. Overall, microsurfacing is very effective when used for the proper application on a road with a sound base structure.

Barry Dunn then took the stage to talk about microsurfacing and slurry seal treatments as preventive maintenance treatments. He believes that agencies often base treatment selection solely on the cost and performance life of a specific product or material, which oversimplifies the problem. One main consideration should always be the condition of the existing pavement. A study found that treatments applied to pavements in good condition have good results, and vise versa. At some point, roadway deterioration accelerates: the condition moves from good to poor and then quickly becomes worse. Tests indicate that visible pavement distress lags behind the condition of the binder in the mix. Once damage becomes visible, the optimal time to perform preventive maintenance has probably already passed.

Microsurfacing and slurry seals are truly preventive maintenance treatments. Therefore, these treatments should be placed before any distress is visible. Early application will seal the mix, maximize binder life, and extend pavement service life. Microsurfacing and slurry seals are especially effective at preventing weathering and oxidation.

Pierre Peltier then took the microphone to discuss quality control of microsurfacing treatments. According to Peltier, the development of clear specifications can greatly improve the quality of a microsurfacing treatment. Agencies have certain expectations going into such a project, like good skid resistance, filled-in voids, and the ability to allow traffic on the road within one hour after treatment. Therefore, it is vital to the success of the project that the agency develop specifications thoroughly enough for the contractor to know what is expected.

Mix design is another major factor affecting quality. The types of materials used should be those specified and selected for the project, and materials testing should be performed on a regular basis, also according to specification. Next, the field inspector and crew must be capable and knowledgeable in their respective areas. Good communication between everyone working on the same project is crucial. The existing pavement condition is also highly important. Finally, a properly prepared surface can increase the quality of a job significantly.

Surface treatments fail due to material incompatibility, improper preparation, improper control of materials during application, poor traffic control, improper road selection, and poor timing. Quality control means avoiding these things and motivating workers to produce the best product possible.

After the presentations, a question and answer session between the audience and the panel began. One audience member asked if micosurfacing is an effective treatment for oxidized and polished pavement. In response, the panel said that it depends upon the existing surface. The surface should be swept clean, and then sometimes a tack coat or fog seal should be laid before a microsurfacing is placed in order to give a really dry pavement some asphalt before the treatment.

For heavily cracked roadways, one solution suggested by the panel was pouring sand into the cracks, then sealing them, and finally sealing the whole pavement with a microsufacing treatment. In many northern states, wide cracks develop due to climatic conditions. These states use special slurry seal/microsurfacing boxes to fill the large cracks or dips in the road. Although large cracks will still return after treatment, they will be more manageable. Another point made about cracking is that while cold mix can be laid on a fresh crack seal job right away, a month's worth of traffic should be permitted before a hot seal goes down over the crack sealing. Thermal cracking will cause cracks to reflect, so a chip seal should be placed first, due to its flexible nature. Then, a microsurfacing treatment can be placed over the chip seal. An audience member was curious as to whether or not scrub seals are effective against thermal cracking. Barry Dunn replied that he would be afraid that skid resistance would be compromised by that treatment.

**Seal Coats** presented by Darwin Lankford, P.E. and Bill O'Leary

Darwin Lankford hails from the rural Childress District in Texas. In his district, the road agency places seal coats on an average of 300 miles of roadway a year, in order to maintain the yearly cycle of sealing. Every September, the agency buys materials for seal coats for the following summer. This district primarily uses AC 15-5TR and tests every load of asphalt to ensure quality.

Still, even though the agency has a well-planned sealing strategy, seal coats usually fail on about 28% of low volume roads and 37% of high volume roads. Penetration accounts for about 75% of all treatment failures. Chip loss wastes tax money, damages windshields, and forces agencies to spend valuable maintenance money stabilizing shelling roads. To help avoid treatment failure, agencies must be firm about testing their materials regularly, visiting with their suppliers, and sending their suppliers the materials test results.

Bill O'Leary then took over to discuss chip seals and binders for seal coats and expand upon Lankford's thoughts on quality control. First, O'Leary explained the logic behind typical binder nomenclature. The name of a binder holds much information, such as whether an emulsion is cationic, anionic, or nonionic and the speed at which the emulsion sets.

O'Leary then informed the audience about a proposal written by the state to enact an assurance quality control program for asphalt binders. The proposal pushes for the grading of suppliers on a scale of 1 to 4. If passed, every asphalt supplier will be required to have a certified testing lab or access to an independent lab in order to receive a high grading score. To receive a high score, a supplier would have to produce no failed materials and have consistent test results. Because the score will affect the company financially, it will be very important to suppliers to meet these qualifications, which could improve material quality dramatically. O'Leary thinks this proposal is a move in the right direction and applauds the state for its vision.

After these two presentations, the floor was open for questions. One audience member was curious if the contractors in Lankford's district still receive payment when there is such a high rate of treatment failure there. Lankford explained that they do, and that the failure is probably due to a flaw in the agency's specifications.

Lankford was then asked if chip seals are planned for the roads in his district or if they are placed based on visual data. He replied that sealing is done primarily due to the results of visual inspection. Every year, a member of maintenance personnel drives all the roads that will potentially receive a seal coat to make sure that the treatment will be appropriate. The district has a schedule for seal coats but also tries to inspect the roads as much as possible.

An attendee asked Lankford if his district has found any treatments that succeed in preventing chip loss. His response was that they have not found anything that is really effective, though they mainly use fog seals at this point. Then an audience member suggested that Lankford's district try to retain the rock in their seal coats by requiring their contractors to fog seal or repair any roads that have chip loss. Another member of the audience stepped forward to say that his contractors have improved significantly over the past few years because he has begun personally inspecting their work. From attending seminars like this year's Pavement Preservation Seminar, he knows what to look for in his contractors' work. Education and the dissemination of knowledge about best practices are the most effective means of improving pavement preservation practices.

**Life Cycle Cost Comparison of Strip Sealing and the Ultra-High Pressure Watercutting Technique for Restoring Skid Resistance on Low-Volume Roads** written by Douglas D. Gransberg, P.E., CCE and Bryan Pidwerbesky, PhD, presented by Bill O'Leary

The traditional treatment for roads with excessive asphalt in New Zealand involves igniting the pavement and burning off the excess binder. A new method has been developed, however, that may prove to be far more effective. The ultra-high pressure watercutter works like a rinse and vacuum tool. The water leaves the device with 30,000 psi.

Though the water hits the pavement with enormous pressure, the machine uses a relatively low volume of water. The water removes excess asphalt and leaves the rock; the machine then vacuums up the water and the asphalt. After the process is finished, the watercutter is filled with about 95% asphalt and 5% water, which means that an insignificant amount of aggregate is pulled up.

Another interesting advantage of this machine is that it is best used in the winter. The cutter works most efficiently on cool, wet pavement. As these are the exact opposite conditions required by most treatments, the cutter can be used when the majority of other maintenance operations have halted.

Gransberg and Pidwerbesky's paper presents a very sound analysis of cost comparisons. The cutter is financially competitive with strip sealing for restoring surface texture even without including the environmental benefits associated with this method in the cost analyses. The watercutter is a more sustainable treatment than laying down new pavement, as it uses no new materials at all.

The new cutter is not being used in the United States at this point, though an American equipment manufacturer has expressed great interest in making this machine. O'Leary predicts that the cutter will be in the States very soon, probably within the next six months. He thinks watercutter retexturizing seems like a very good method, as it actually solves pavement problems rather than just covering them up.

The audience was curious as to whether or not the asphalt removed with the cutter could be recycled and reused. O'Leary said that it could be, though this is not the current practice in New Zealand. Reusing these materials could make the watercutter even more cost-effective and environmentally friendly.

Several audience members were concerned about the purchase price. O'Leary responded that the latest estimate is a couple hundred thousand dollars.

Finally, a member of the audience described seeing a demonstration of a similar tool. This tool had a very small cutting head and was used to remove striping from the pavement. He said it removed the striping very well, and that the pressure and pattern, as well as the amount of time a section of pavement is focused on, could be adjusted to control the amount of binder removed. He and all who saw the demonstration with him were very impressed. O'Leary agreed that there are similar machines to the watercutter from New Zealand being used in the United States, but the main difference is the amount of water used. The tools in the U.S. tend to use a substantial volume of water, whereas the New Zealand watercutter requires a very small amount of water to achieve similar results.

2007 Pavement Preservation Seminar Participants: (from left) Dr. Yetkin Yildirim, Darwin Lankford, Bill O'Leary, Paul Montgomery, and Barry Dunn

THE UNIVERSITY OF TEXAS AT AUSTIN + COCKRELL SCHOOL OF ENGINEERING

TxDOT

# TEXAS PAVEMENT PRESERVATION CENTER Newsletter

ISSUE 9 / WINTER 2008

**Winter 2008 / Issue 9**

**Inside This Issue:**



## Our Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost.

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## Issue Highlights

### TRB 87th Annual Meeting

The Transportation Research Board is a division of the National Research Council, which serves as an independent adviser to the federal government and others on scientific and technical questions of national importance. TRB's mission is to promote innovation and progress in transportation through research. The Transportation Research Board's 87th Annual Meeting will bring more than 10,000 transportation professionals from around the world to Washington, DC on January 13-17, 2008. The TRB Annual Meeting program will consist of over 3,000 presentations in 600 sessions. Summaries of selected seminar papers related to pavement preservation will be included in the next issue.

### Mark Your Calendar: TPPC Seal Coat Training Courses

As part of our continuing efforts to advance the field of pavement preservation, the Texas Pavement Preservation Center is proud to offer two new training courses on seal coats, also known as chip seals. Each course is designed to primarily target one group of maintenance professionals: "Seal Coat Inspection and Applications" is intended mainly for inspectors, while "Seal Coat Planning and Design" is tailored to the educational needs of maintenance engineers. The courses have 6 and 5 chapters, respectively, and cover topics from pavement preservation concepts to equipment inspection. All those attending one of the approximately 8 hour long courses will have the opportunity to receive 0.8 Continuing Education Units (CEUs), provided they score above passing on the corresponding quizzes. The first two rounds of courses will be held in Fort Worth on February 27-28 and Austin on March 18 and 19. The final round of courses will be in Lubbock, TX from April 15-16. For more information on this and other continuing education courses, or to request a course in your area, contact Dr. Yetkin Yildirim at yetkin@mail.utexas.edu.

### 2008 – TxAPA Seal Coat Conference

The Texas Asphalt Pavement Association (TxAPA) and Texas Department of Transportation (TxDOT) held their 2008 West Texas Regional Seal Coat Conference on February 5-6, 2008 in Abilene, Texas. The conference is designed to provide seal coat inspectors, seal coat managers, and maintenance seal coat crews with a comprehensive overview of the current safest and most efficient practices for seal coat operations. This year's presenters included Kelly Durham, Tom O'Leary, Steve Douglas, David Stroud, Bill Wiese, Chuck Dannheim, and Pat Wootton. Their presentation topics ranged from best practices in seal coating, seal coat asphalts and aggregates, cold weather seals, fog seals, chip seals, crack seals, and prime seals. All of the presenters worked hard to demonstrate how seal coats affect Texas pavements in order to improve road safety and increase our knowledge of pavement preservation methods.

### **Chip Seal Equipment: General Information** presented by Kelly Durham

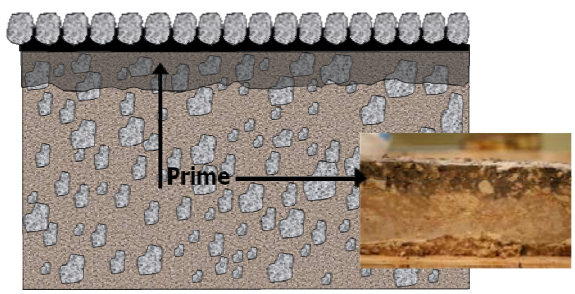
Kelly Durham's presentation focused on chip seal equipments and proper chip application. Durham emphasized that operation safety comes from knowledge of the materials and equipment used in the sealing process. Therefore, it is important for all attendees to understand how asphalt is made, how the vehicles used for sealing work, and the general process of chip seal application. Durham listed poor weather conditions during construction as a major cause of many chip seal failures and suggested that construction should take place in mild or warm weather. The presentation concluded with a few notes on workmanship. Durham strongly emphasized that success results from good teamwork; it is therefore imperative for the whole crew to be on the same page. Durham's presentation showed that while it is important to correctly calibrate sealing equipment and prepare against weather conditions, it is equally important to calibrate the work crews.

### **Seal Coat Best Practices** presented by Tom O'Leary

O'Leary's presentation discussed the best and most efficient seal coat application techniques. In order to improve seal coat practices, he suggested that preservation crews focus on the life expectancy of the road and how to improve pavement safety, work with the limitations of the seal coat, and take note of the public's response to the various aspects of road repair. O'Leary listed the following as the five keys to success: 1) Timely, quality prep work around 90 to 180 days before construction begins, 2) Surface inspection the day of the application to determine rates and make knowledgeable adjustments in the field, 3) Use of variable rate spray bars and modified emulsions/asphalts on higher volume roadways 4) Timely application of asphalt and aggregate to optimize aggregate embedment, and 5) Re-visiting previous jobs to learn what worked and what did not.

### **Prime Seals, Cool Weather Seals, Multiple Course and Fog Seals** presented by David Stroud, Steve Douglas, and Bill Wiese

This presentation had three different sections. The first identified the primary functions of a prime coat and explained the types of base materials used. It also reviewed the rewards, risks, optimum conditions, and problems facing cool weather seals. The presenter explained the function of a double seal and finished his portion of the presentation by providing tips on how best to correct bleeding and raveling/rock loss should either occur.




The second portion of the presentation focused on seal coat preparation. The presenter provided information for various types of seal coat, including fog seal and crack seal, and gave tips on using herbicide and repairing pavement edges. The presentation also emphasized the importance of repairing the cause of pavement failures, rather than just patching over them. The crew should complete all repairs at least three months prior to seal coal application and select the appropriate aggregate and asphalt application rates for each road under treatment. If done correctly, a seal coated roadway may last five to seven years.

In the last section of the presentation, Steve Douglas explained the functions of fog seals and their application and dilution rates, as well as some construction guidelines to improve performance life. Douglas ended his portion of the presentation with a summary of the advantages to using fog seal in road repair: it is inexpensive, effective, efficient, and acceptable on most surfaces.

**Seal Coat Asphalts** presented by Chuck Dannheim

Dannheim's presentation first identified the two types of seal coat asphalt: hot applied and emulsion. Within hot applied asphalts, there are two more types: one is pure asphalt cement and the other is polymer-modified asphalt cement. During the application of hot applied seal coat, a pre-coated aggregate is recommended. Hot applied products are designed for efficient quick applications but leave little room for mistakes. Emulsions are ideal for situations requiring just the opposite. They have three classifications: anionic (meaning negatively charged), cationic (positively charged), and nonionic (neutral). It is recommended that emulsions are used with "non-coated" aggregate. They have a slower cure time, provide a big margin of error, and are easier than hot applied products to work with.

**Seal Coat Aggregates** presented by Pat Wootton

Wootton discussed the different types of aggregate available. The types used in Texas include crushed stone, crushed slag, crushed and uncrushed gravel and traprock (basalt). Wootton also highlighted the difference between the various surface aggregate classifications, identifying Class A and B as normally required for surface treatment, with Class A as an aggregate which only allows blending for HMA. Another aspect of the presentation focused on seal coat aggregate properties: Wootton demonstrated the effects of different properties on pavement performance. For example, different mineral types affect the pavement's resistance to polishing, affinity for asphalt absorption, and skid resistance. Finally, the presentation concluded with information on testing procedures for seal coat aggregates. Wootton emphasized that in order to correctly access the procedures, crews must obtain an adequate sample size from non-segregated sampling locations.

*2008 TxAPA Seal Coat Conference participants*

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COCKRELL SCHOOL OF ENGINEERING

# TEXAS PAVEMENT PRESERVATION CENTER

TxDOT

# Newsletter

ISSUE 10 / SPRING 2008

**Spring 2008 / Issue 10**

## Inside This Issue:

### Proceedings from the TRB 87th Annual Meeting



## Our Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost.

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## Issue Highlights

### TRB 87th Annual Meeting

The Transportation Research Board is a division of the National Research Council, which serves as an independent adviser to the federal government and others on scientific and technical questions of national importance. TRB's mission is to promote innovation and progress in transportation through research. The Transportation Research Board's 87th Annual Meeting attracted more than 10,000 transportation professionals from around the world to Washington, DC January 13-17, 2008. The TRB Annual Meeting program consisted of over 3,000 presentations in 600 sessions. Summaries of selected seminar papers related to pavement preservation are included in this issue.

### TPPC Seal Coat Training Courses

As part of our continuing efforts to advance the field of pavement preservation, the Texas Pavement Preservation Center is proud to offer two new training courses on seal coats, also known as chip seals. Each course is designed to primarily target one group of maintenance professionals: "Seal Coat Inspection and Applications" is intended mainly for inspectors, while "Seal Coat Planning and Design" is tailored to the educational needs of maintenance engineers. The courses have 6 and 5 chapters, respectively, and cover topics from pavement preservation concepts to equipment inspection. All those attending one of the approximately 8 hour courses will have the opportunity to receive 0.8 Continuing Education Units (CEUs), provided they score above passing on the corresponding quizzes. The first three rounds of courses were held in Fort Worth on February 27 and 28, Austin on March 18 and 19, and Lubbock, TX April 15 and 16. For more information on continuing education courses or to request a course in your area, contact Dr. Yetkin Yildirim at yetkin@mail.utexas.edu.

**Spray Applied Surface Seal Study: Fog and Rejuvenator Seals** by Gayle N. King and Helen W. King

Although fog and rejuvenator seals have been traditionally used by agencies for a variety of purposes, such as preventing surface cracks, many agencies have begun to discontinue the use of these treatments due to safety concerns. Although they are the least expensive pavement preservation treatments, fog and rejuvenator seals are commonly believed to cause a reduction in skid resistance. The purpose of this study was to determine how effective these seals are, to what extent safety is affected by them, and if these safety hazards can be mitigated by taking certain precautions. To this end, the authors collected existing information on the subject and placed several test sections on roads with different climates, traffic levels, and surface characteristics. The authors then evaluated the field and lab test methods used and analyzed the data collected from the experimental road segments.

The authors crafted their study plan from the results of four state-of-the-knowledge workshops in 2001 and 2002. They found that emulsified sealers and rejuvenators work best as preventive maintenance treatments on pavements that have begun to age but are still in good condition. The use of these treatments is limited to asphalt pavement with sufficient permeability to allow emulsion infiltration. Until the seals have fully cured and friction returns to an acceptable level, traffic must be strictly controlled. The cure time for these sealers depends upon the emulsion, existing pavement, and climate. In King and King's 2007 trials, the amount of time before traffic could return to full speed varied between 15 minutes and 4 hours.

Sanding is another method used to mitigate the loss of friction or reduce the amount of time required before ceasing traffic control. As long as loose the sand is cleaned away before traffic is allowed to travel at full speed, sanding can be very effective at increasing early friction levels; sanding on the 2006 projects showed an immediate increase in friction values. The emulsion residue rheology should form the basis for sanding strategy design. Harder residue emulsions, for instance, allow almost immediate sand application following a fog seal. For softer residue emulsions, it is recommended that sanding be performed at least 20 to 40 minutes after fog seal application to avoid leaving oil-saturated sand on the surface.

Even when precautionary measures are taken, however, fog seals should never be used on a pavement that already exhibits poor surface texture or low friction numbers. Furthermore, roads with large cracks, rutting, shoving, or structural deficiencies are not good candidates for fog sealing.

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**Life-Cycle Cost Optimization of Highway Maintenance and Rehabilitation Strategies Based On an Integrated Maintenance Management System** by Yuanjie Xiao, Fujian Ni, Jingli Du, and Qiao Dong

Many different systems and applications for pavement management exist, with designs ranging from basic to extremely complex. The commonly used methods all have flaws, however. Xiao, et al. have identified some of the most typical problems and propose a new maintenance management system to combat these problems. Most management systems support either network-level or project-level decisions, which inhibits the integration of maintenance planning with scheduling and budget allocation. Many maintenance systems focus primarily on pavement and bridge maintenance while ignoring the care required to maintain roadside appurtenances, such as guardrails, signs, and lighting facilities.

In order to overcome these common shortcomings, the authors developed a comprehensive framework for highway maintenance. The main focus of the study was to formulate a practical life-cycle cost analysis (LCCA) and optimize the maintenance, repair, and renovation (MR&R) activities at both the project and network level.

The pavement management system developed by the authors uses Markov-chain deterioration models to predict the performance of highway facilities. These models are effective because they can capture the time-dependent and uncertain nature of the deterioration process, maintenance operations, and initial pavement condition. The system includes a comprehensive cost elements analysis, which is designed to minimize the total life-cycle MR&R costs while optimizing highway performance. The system uses a genetic algorithm to deal with the scale of this problem. The authors tested the applicability of this system using real-world data from the Jiangsu Department of Transportation and found it to be an effective method for pavement maintenance management.

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**Safety Effect of Preventative Maintenance: Microsurfacing, a Case Study** by Tara Erwin and Susan L. Tighe

First and foremost, pavement maintenance operations are meant to improve driver safety. However, many agencies simply assume that the application of a treatment will make roadways safer without any empirical evidence. Erwin and Tighe realized that the Region of York transportation department in Ontario was using microsurfacing treatments to improve pavement surface conditions without first understanding the effect these treatments have on safety. Therefore, the authors conducted a before-after study designed to show how microsurfacing affects safety conditions.

This study used data from the Region of York to compare the crash experiences on roadways before and after a microsurfacing treatment was placed. The authors assumed that if everything else remained the same, the crash experience before the treatment would be a good estimate of what would have happened without improvement. The study utilized a file that listed the microsurfacing treatments by number, year, location, and type, as well as a file that provided crash data from between 1999 and 2005 for the treatment sites listed in the first file.

The results of this study show that microsurfacing is generally effective at improving road safety, with crash reduction factors as high as 54 percent. The study found them to be most beneficial at sites that are often wet or slick and/or have a high occurrence of severe crashes, intersection-related crashes, and/or rear end crashes. Further research exploring how pavement maintenance impacts safety conditions should be performed to enable agencies to make the best and safest management decisions possible.

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**Pavement Performance Evaluation and Prediction Based on Extension Theory** by Qiang Li and Kelvin C.P. Wang

Li and Wang introduce a new pavement performance evaluation and prediction methodology based on extension theory, a knowledge system developed to solve contradictions and incompatibility problems that uses the concepts of matter-elements and extension sets. Because pavement performance criteria are frequently inter-related with unclear quantitative relationships, Extension Theory is potentially an excellent method for discovering the quantitative interactions between them. In this study, Li and Wang used the performance criteria found in the Mechanistic Empirical Pavement Design Guide (MEPDG) and information from the LTPP database to create comprehensive quantitative performance predication models based on Extension Theory.

Once the authors completed designing the procedures of the evaluation process, they conducted case studies to develop performance prediction models. The pavements were then compared and analyzed, revealing that the models developed by Li and Wang were effective at predicting the quantitative deteriorations of the overall pavement performances.

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**Understanding the Effects of Aggregate and Emulsion Application Rates on the Performance of Asphalt Surface Treatments** by Ju Sang Lee, Ph.D. and Y. Richard Kim, Ph.D., P.E.

Asphalt surface treatments (ASTs) are commonly used by many state Departments of Transportation (DOT) for pavement preservation. The amounts of emulsion and aggregate used in these treatments often are not regulated by protocol but are chosen based on experience. The guidelines that exist for aggregate and emulsion application rates (AARs and EARs) are just general descriptions of the typical rates found in ASTM and used by some state DOTs. This study seeks to develop a method for determining the optimum AAR and EAR for each individual preservation project.

The typical AST performance failures due to improper application rate design are bleeding and aggregate loss, which are generally caused by too little or too much aggregate or emulsion. In this study, the third-scale Model Mobile Loading Simulator, MMLS3, a unidirectional vehicle load simulator that uses a continuous loop for trafficking, was used along with the digital image processing (DIP) technique. This combination allowed for the development of a new comprehensive AST performance test procedure that can make evaluations using realistic loading conditions. The new test was used in this research to assess the performance of ASTs utilizing different AAR and EAR combinations on samples with two differently graded aggregate types.

According to this study, the newly developed test method is very effective at evaluating AST performance. The factor most affecting AST performance was found to be aggregate gradation. Furthermore, the study developed a method for determining the optimum AAR and EAR for individual projects. The results were found to be accurate by a blind test performed by two independent organizations. Finally, the study discovered a dependent relationship between the reference voids in AST, the voids in the loose aggregate, and the aggregate gradation type.

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**Development of a Sampling Protocol for Condition Assessment** by Ricardo A. Medina, Ali Haghani, and Nicholas Harris

The objective of this study is to improve the Peer Review Measurement Program established by the Maryland State Highway Administration (SHA) by developing a sampling protocol. The program is intended to assess the condition of the highways and roadsides maintained by SHA and evaluate the level of service (LOS) provided to the customers using these facilities. LOS is calculated using the percentage of assets that meet or exceed either predefined or desired maintenance conditions; LOS is the basic measurement of the condition of each asset in the road system.

The four categories of assets examined in this study are shoulder, drainage, traffic & safety, and roadside. Presently, the data used to find the LOS for each individual county and the state as a whole come from field surveys. In the current system, samples for the surveys are taken randomly, meaning that certain mitigating circumstances, such as roadway functional classification and average annual daily traffic (AADT), are ignored. These samples may not be of sufficient size and diversity to represent the whole of the agency's assets. To remedy this problem, Medina et al. sought to develop a sampling protocol for condition assessment based on the level of confidence and precision desired. To this end, the authors studied the effect of sample size on the accuracy of LOS estimates.

The study concluded that, for a given level of confidence and precision desired, the size and distribution of the samples required for the annual peer review of each maintenance shop are functions of four parameters: the number of centerline miles in each shop, the stratification assets in the region, the distribution of the assets throughout the system, and the estimates of the population variants in each stratum. The system outlined in this study can provide sound information to agencies, allowing them to more effectively prioritize locations in need of maintenance and make better choices regarding the allocation of funds, personnel, and equipment.

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**Bituminous Surface Treatment Protocol for the Washington State Department of Transportation** by

Jianhua Li, Stephen T. Muench, Joe P. Mahoney, and Linda M. Pierce

In an effort to reduce the costs of pavement preservation activities, the Washington State Department of Transportation (WSDOT) is considering using a bituminous surface treatment (BST), also known as a chip seal or seal coat, as an alternative to hot mix asphalt (HMA) overlays. In an average cost comparison from 1995 to 2007, the typical WSDOT BST surfacing treatment was about one-tenth the initial price of the typical WSDOT HMA overlay. The purpose of this study is to find the best strategy to increase the amount of BST used instead of HMA, create a life-cycle cost comparison between the two treatments, and identify the difference in lifelong condition between roads with a BST and those with an HMA overlay.

Li et al.'s paper reports on the first stage of a two-part study that examines the best times and locations for BST application using modeling software to predict long-term cost and condition. The follow-up study will explore the feasibility of increasing BST use and how to implement a strategy to do so if the results are positive.

For the first part of the study, the authors used the Highway Development and Management System (HDM-4), a powerful pavement management software tool. With this system, WSDOT was able to find a maximum AADT and traffic loading allowed on a BST surfaced road and the best strategy for integrating BST surfaces with existing HMA overlaid pavements. Results showed that the HDM-4 modeling system is capable of providing valuable information on both pavement condition and life-cycle costs. The research found that the life-cycle cost of BST is not lower than that of HMA; it is merely shifted from the agency to the user. Whether or not this shift is feasible will be the focus of the authors' next study.

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**Rolling Wheel Deflectometer-Based Pavement Management System Success: Champaign County, IL** by William R. Vavrik, Ph.D., P.E.; Douglas A. Steele, P.E.; and Jeff Blue

In Champaign County, IL, engineering judgment has traditionally been the main tool used by the county highway department for planning, programming, and implementing road improvement activities. Because of recent budget issues due to a need for spending on roads not owned or maintained by the County, the department is interested in making more informed and efficient pavement management decisions.

The Champaign County highway department contracted an independent company to design an effective pavement management system (PMS) that would help reach the agency's objectives. The new PMS is intended to provide the County Engineer with better decision-making tools that will clarify the potential outcomes of certain investment decisions. It should accurately describe what is needed to either maintain or improve the county's highways and incorporate a pavement preservation program into the system. The PMS is also meant to be a science-based tool that can impartially allocate scarce funds among the competing sectors. Finally, the agency will become a leader in the use of PMS technology by being the first transportation department to utilize the Rolling Wheel Deflectometer for evaluating pavement structural conditions throughout the network and use those measurements in project and treatment selection.

The authors conclude that the use of the RWD to assess the structural condition of a road can eliminate the application of pavement preservation treatments to roads that are structurally inadequate. The new PMS has improved decision-making by using quantifiable data, standard evaluations, models, and economic analyses to weigh the alternatives rather than relying on the opinions of engineers alone.

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**User Cost Models for Improved Pavement Selection** by O. Salem, Ph.D., P.E., CPC; Dr. Ashraif Genaidy; Abhijeet S. Deshpande; and Tony G. Geara

A growing concern in the transportation community is the exclusion of user cost comparisons in most current pavement selection methods. Recently, decision makers have begun to realize that user costs during the life of a pavement may be far more significant than the initial construction and miscellaneous costs for which the agency is responsible. User costs are those incurred through accidents, traffic and business disruptions, increased travel time, pollution, increased fuel consumption, or vehicle repairs

User costs do not just affect customer satisfaction but can have a very real impact on the local and national economies. Many increases in user costs are directly related to the type of pavement selected by a transportation agency. Therefore, agencies must be aware of all the potential user costs associated with each alternative pavement design and construction strategy.

This research study was undertaken in order to improve the Ohio Department of Transportation's (ODOT) pavement selection process by adding user cost analyses. Two alternative methods were developed from the results of a rigorous study of current user cost analysis practices from US and Canadian state departments of transportation. This study consisted of a review of ODOT's own practices, the creation of a comprehensive questionnaire survey of other state and provincial DOTs, an examination of user cost models, and an objective evaluation of the effectiveness of the developed methodology.

One of the approaches examined in this study is to incorporate user costs into life cycle cost analyses. This approach is the one currently used by all of the surveyed DOTs that considered user costs when selecting a pavement. The second approach involves comparing user costs of alternatives with equivalent life cycle costs. The authors recommend using RealCost software, developed by FHWA, to quantify user costs when taking this alternative approach.

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THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COCKRELL SCHOOL OF ENGINEERING
TEXAS PAVEMENT PRESERVATION CENTER
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Newsletter
ISSUE 11 / SUMMER 2008

**Summer 2008 / Issue 11**

**Inside This Issue:**

## The TPPC Seal Coat Training Course



### TPPC Board of Directors



### Our Mission

The mission of TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

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### Issue Highlights

### TPPC Seal Coat Training Course

As part of our continuing mission to advance the field of pavement preservation, the Texas Pavement Preservation Center has begun two new training courses on seal coats, the Texan term for chip seals. The courses are intended to serve two main groups: engineers and inspectors. The course designed for inspectors, entitled “Seal Coat Inspection and Applications,” focuses on proper inspection methods and the equipment used during chip seal construction. The other, “Seal Coat Planning and Design,” is intended to instruct engineers on planning, designing, and constructing chip seals. The purpose of both courses is to increase the awareness and understanding of pavement preservation by providing instruction on a common preservative maintenance treatment. This issue offers a summary of the material presented in the course, allowing those who are unable to attend an official class to still glean some knowledge from our efforts.

The first three rounds of courses were held in Fort Worth February 27 and 28, Austin March 18 and 19, and Lubbock, TX April 15 and 16, 2008.

Both sections of the course are approximately 8 hours in length and offer attendees 0.8 Continuing Education Units. To receive a certificate of completion for the course, all attendees must score a passing grade on a series of quizzes over the material covered. For more information on continuing education courses or to request a course in your area, please contact Tammy Sims at tsims@dot.state.tx.us.

## Seal Coat Inspection and Applications, MNT 702

This course focuses on proper inspection methods and the equipment used in seal coat construction. The course is composed of six chapters, which will focus on the need for a pavement preservation strategy applied across the state in all seal coat applications, inspector duties and authority, equipment inspection and calibration, seal coat terminology, pre-seal coat repairs, seal coat defect identification and correction, seal coat preparation, and seal coat and surface treatment application. Additionally, attendees participate in two lab activities, one on binder application rates, and another explaining field inspection of a distributor. The following is a brief summary of each chapter from this course and the binder lab.

### Chapter 1: Pavement Preservation Concepts

The first chapter relates the basic principles behind pavement preservation and explains the need for training in this area. The idea of pavement preservation is relatively new, and is therefore not fully understood by many maintenance professionals. This course is part of a nationwide effort to increase public awareness of the benefits of pavement preservation practices.

A pavement preservation (PP) program is defined by the Federal Highway Administration (FHWA) as a program that employs a network-level, long-term strategy that enhances pavement performance using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet motorist expectations. These programs use both preventive and routine maintenance, though the emphasis definitely lies with prevention. Basically, pavement preservation works because maintaining a road in good condition is easier and less expensive than repairing one in poor condition.

PP is a very effective strategy for many reasons. It extends pavement life and arrests or retards deterioration and progressive failure. PP keeps the road in good condition, which improves safety conditions and ride quality and increases road user satisfaction. Furthermore, the financial savings from using preventive maintenance as opposed to reactive maintenance are substantial.

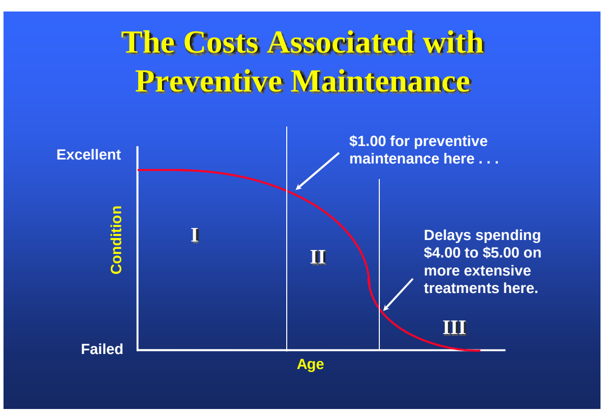


**Figure showing the financial benefits of preventive maintenance**

Pavement preservation treatments are used for planned maintenance, maintenance to retard future deterioration, and actions that maintain or improve the pavement's functional condition. The most common treatments include chip seals, slurry seals, fog seals, micro-surfacing, thin HMA overlays, crack sealing, and joint sealing.


**Dr. Yetkin Yildirim, director of the TPPC, explains the importance of pavement preservation at the Austin seal coat course.**

The main philosophy behind pavement preservation can be summed up by the well-used mantra "the right treatment, the right road, and the right time." This catchphrase highlights the importance of careful planning in a preservation strategy. The best time and location for treatment must be identified, which often means selecting a pavement that does not have extensive or even minor visible damage. Once a project is chosen, maintenance professionals have to decide on the most effective treatment for the conditions at hand, including traffic levels, climatic conditions, treatment cost, and distress type and extent.

Because pavement preservation is a fairly new concept, many road agency personnel lack sufficient knowledge of when and where to apply a preventive maintenance treatment, what materials to use, and which methods are preferable. Unfortunately, there is currently only a limited number of resources providing formal training on preventive maintenance. This problem must be corrected, as education on pavement preservation is needed at all levels. Policymakers, field personnel, engineers, and taxpayers all affect road maintenance decisions, so all must learn about the advantages of pavement preservation. The aim of this course is to improve the current state of pavement preservation knowledge.

### Chapter 2: General Principles

This chapter focuses on seal coat terminology, the need for and limitations of seal coats, the factors that could affect seal coat performance, and the defects that commonly occur in seal coats and surface treatments.

Seal coats are most commonly called chip seals, though they are known by many other names, such as a skin coat and a spray and chip. They are inexpensive in comparison to other preventive maintenance treatments, and are usually very simple and highly effective. They compose a major part of TxDOT's pavement preservation program. A seal coat is a layer of asphalt binder covered with aggregate and is always applied to an existing pavement. If the same treatment is applied to a prepared compacted base, it is known as a surface treatment. Seal coats usually last about six to eight years, though some have been known to last as long as twenty.

**A typical strip seal coat covers the right-hand lane of this road.**

Seal coats have many useful functional characteristics: sealing an existing bituminous surface against water and air, enriching a dry or raveled surface, arresting light deterioration, providing skid-resistance, providing desirable surface texture, improving light-reflecting characteristics, enabling paved shoulders or other features to be demarcated by a different texture or color, and providing a uniform appearance. The aggregate layer successfully resists traffic abrasion and transmits wheel loads, creating a durable surface for the roadway on which it is applied.

Seal coats do have limitations, however. Although a seal coat can preserve the strength of an existing pavement and subgrade by preventing water infiltration, this treatment has little to no structural strength in and of itself. Seal coats are only a temporary fix for load-associated cracking and cannot effectively improve ride quality. Flushing and bleeding are difficult to repair with seal coats. Furthermore, although seal coats have been used successfully on roads with both low and high amounts of traffic, they are usually more effective on roads with low traffic volumes and are most effective on roads with low-volume truck traffic.

Many different factors can affect seal coat performance, though construction techniques are probably the most significant. Other factors affecting performance include the properties and amounts of binder and aggregate, the uniformity of the binder and aggregate application, and the initial amount of adhesion between the existing surface, the new binder, and the new stones. The condition of the existing pavement or strength of the underlying base, the amount and type of traffic traveling the roadway, and the environmental and drainage conditions can certainly influence seal coat performance, as well.

A surface treatment, which is a seal coat placed on a granular base rather than an existing paved surface, is mainly impacted by the materials and construction quality of the base course. Delamination of the surface treatment from the base is the most common failure associated with this treatment. To prevent delamination from beginning, the base finish must be performed with care. Slush rolling is not recommended: if too much water is used, the base may be weakened significantly.

The prime coat can also greatly affect the performance of a surface treatment. Surface treatments must be constructed with strong and durable binders, which do not have the low viscosity needed to penetrate and grip the base layer. The prime coat's primary purpose is to grip both the base and the surface treatment, holding them together and preventing debonding.

The most common faults found in seal coats or surface treatments are loss of aggregate, streaking, and flushing. Loss of aggregate is usually caused by poor adhesion between the binder and the stone, which is often due to insufficient binder temperature during application. If the aggregate is not placed before the asphalt begins to cool or an emulsified binder begins to cure, the stones cannot embed properly because the binder is already too hard. Similarly, late season application can cause problems. An insufficient amount or improper type of binder, dusty or moist aggregate, excessive rock application, and premature high-speed traffic can all result in chip loss, as well. Streaking is caused by a lack of uniformity in the binder application, and flushing is the result of too much binder. With proper construction and design, all three of these common defects can be avoided.

**Non-uniform binder application can cause streaking.**

## Chapter 3: Duties of Inspector or Crew Chief

This chapter focuses on the authorities and duties of an inspector or crew chief and the specifications and plans a project must follow. Primarily, the inspector is a representative of the project engineer, whose duty is to ensure that all aspects of the contract, including the plans, specifications, and other documents, are adhered to during the construction process. Inspectors therefore have the authority to shut down a project if all the requirements of the contract are not met. The inspector should have a firm grasp of the details of the contract, the plans, specifications, special provisions, and work schedule for the project and must inspect all work, materials, and equipment involved. Every material must be sampled, inspected, tested, and approved prior to use. Otherwise, the inspector may order the contractor to remove and replace the material.

**Attendees answer questions about the previous chapter on a quiz at the seal coat course in Austin.**

The inspector can reject materials or suspend construction if an issue arises between the contractor and inspector until the project engineer can resolve the conflict. The inspector does not have the authority to revoke, alter, or release the contractor from any part of the contract or approve any work that is not performed according to plan. The contractor is responsible for managing the work and supervising construction; the inspector should not interfere with the contractor's duties. If the seal coat work is being done by state forces, however, the crew chief must act as both the chief inspector and supervisor.

TxDOT specifically recommends assigning at least three inspectors to a team for any given seal coat project. A useful strategy can be to use the same inspection team throughout the district each year, which encourages consistency and allows the team to gain knowledge and improve seal coat construction over time. Every team should be equipped with a very experienced and knowledgeable chief inspector, whose duties are to inspect the entire job and determine the binder and aggregate application rates. The other two inspectors will each monitor either the binder or aggregate application and control application rates based on the chief inspector's instructions. All inspectors must report to the project engineer with updates on the progress of the work.

The specifications in the following contract documents must be adhered to in all aspects of the seal coat construction: TxDOT's Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges; Special Specifications; Special Provisions; and Plans. Standard Specifications address the quality of materials and equipment to be used, the method and manner of the work to be performed, and the method of measurement and payment upon completion of the project. Special Specifications are those that are not covered by the Standard Specs and are unique to the individual project. Special Provisions can either revise or supplement the Standard or Special Specs, and the Plans describe the work to be performed in detail.

## Chapter 4: Pre-Seal Coat Activities

The goals of this chapter are to outline the preparation and repairs that may need to be performed prior to placing a seal coat, explain how to properly stockpile aggregate, and discuss the planning and execution of an effective preconstruction meeting. In preparation for a seal coat project, five main steps must be taken: repairs and patching; stockpiling, sampling, and testing aggregate; addressing traffic control needs, holding a preconstruction meeting, and selecting application rates.

Though there is no hard and fast rule as to when repairs should be performed prior to seal coat application, it is generally recommended that they be completed as far as eight months in advance. More important than the amount of time that has passed, however, is that the repair materials have fully cured before the seal coat is placed. Seal coating a fresh patch, for instance, may lead to aggregate loss later on. To ensure that repairs are well-timed, the repairs should be planned and coordinated as soon as possible.

**Fresh patches should be fog sealed prior to seal coat application.**

Some of the repairs that may be needed prior to seal coat application are milling/planing, level-up, pothole repair, base repair, edge repair, and crack sealing. Generally, all cracks greater than 1/8" wide must be sealed prior to seal coat placement.

TxDOT allows contractors to stockpile aggregate at certain approved locations on the project site, though some procedures must be followed before the stockpiles can be placed. The supplier must be identified to the engineer by the contractor after the contract is awarded. The aggregate must be tested according to the plans, specifications, and special provisions. Usually the contractor requests locations for the stockpiles, and the project engineer either approves or denies their proposal. Standard Specifications in Texas require that the location be at least 30 feet from the roadway, does not obstruct traffic or sight distance, and does not interfere with road access from abutting property or with roadway drainage.

Stockpile locations should prevent contamination, and the techniques utilized should prevent or minimize segregation and degradation. If necessary, the contractor may have to prepare the stockpile area before the aggregate is placed by dozing or clearing away debris.

The preconstruction meeting is an important part of the preparation necessary to effectively plan a seal coat. During this meeting, all the personnel involved in the project should be introduced to one another and establish a working relationship. The responsibilities of all project personnel must be clearly defined, the work schedule must be planned, traffic control procedures need to be reviewed, the number of work days and holidays should be identified, and any other pertinent information should be discussed at the preconstruction meeting. All personnel available should attend, but it is highly recommended that at least the project engineer, area engineer, maintenance supervisor, director of maintenance, district laboratory engineer, and inspectors all be at the meeting.

## Binder Application Rate Determination Lab

A hands-on activity accompanied Chapter 4 of the Seal Coat Inspection and Applications course. The exercise is intended to demonstrate how binder application rates are determined.

Attendees conducted a Board Test with samples of aggregate, in which the rock was poured out onto a flat metal sheet until the person pouring felt that a good rock spread for a seal coat had been achieved. Gerald Peterson, who was leading the activity, pointed out that each board had a slightly different amount of rock, showing that “good” rock spread can be a subjective matter. Therefore, a standard for aggregate spread should be set at the preconstruction meeting.

Once the rock spread rate has been determined, the binder application rate can be calculated. If there are fewer voids between the rocks, less binder should be used to avoid flushing.

To check embedment, a single rock can be extracted from the binder, making it easy to see how much of the rock was encased in asphalt. The rock will become more deeply embedded once traffic has traveled over it. If the aggregate is not achieving adequate embedment, the binder may not be hot enough or the aggregate spreader may be too far behind the asphalt distributor.

The second part of the lab consisted of examining several binder samples. One sample was cutback asphalt. With cutbacks, water contamination may be a significant problem, but one of the biggest drawbacks to this type of binder is the volatility of the solvent used. All maintenance personnel must be aware of the potential for ignition from any type of spark or fire.

Cutbacks are not the only dangerous type of binder, however. Modified asphalt binder must be heated to about 350° F for application, making it very hazardous to the maintenance crew spraying it.

When using emulsions, it is important to note that cationic and anionic emulsions cannot be mixed: the result is a gooey ball that cannot be applied to the road. Therefore, the distributor must be cleaned thoroughly if switching between these two different types of emulsion. As for rapid versus medium setting (RS and MS) emulsions, Peterson recommends spraying RS emulsions as soon as possible, while slower-setting emulsions can be stored for a few months. The best way to avoid using binders that are no longer effective is to sample them frequently.

**Gerald Peterson, P.E. pours a binder sample during the lab in Fort Worth.**

## Chapter 5: Equipment Inspection

In this chapter, the typical pieces of equipment required for a seal coat application are listed, and their general inspection procedures are described. This lesson covers rotary brooms, asphalt distributors, aggregate spreaders, haul trucks, rollers, front-end loaders, and heater and storage units. Though the inspector should come to the project with a thorough knowledge of the equipment that will be used, the contractor is responsible for providing a manufacturer’s manual for each piece. These manuals should be used as a reference whenever the inspector needs to verify or look up information on proper equipment inspection techniques.

The contractor and engineer usually decide on a start date for construction and select a date and time for equipment inspection. At least half a day should be set aside for initial equipment inspection, and inspection should be performed at least one day before construction. Visual inspection for leaks should be performed on all equipment both before the project begins and throughout the entire construction process. Not only could a leak be a possible safety issue, but the leaking substance might contaminate the asphalt or aggregate, preventing proper adhesion.

Safety is of the utmost importance on the job site. The manufacturer's safety procedures for inspection and operation of each piece of equipment should be followed at all times. Working with asphalt materials is nearly always somewhat dangerous. Cutback asphalt binders are the most risky due to the extremely flammable nature of the solvents in the mix. The main safety concern with asphalt cement is the high temperature of the binder, which can cause severe burns. A copy of the Material Safety Data Sheet (MSDS) should be kept with the asphalt distributor truck.

A rotary broom is a self-propelled, four-wheeled piece of equipment with a bristle brush that can be raised, lowered, and rotated horizontally that is used to clean the pavement prior to construction. The first step when inspecting this piece of equipment is to identify the relevant data, such as the manufacturer's name, model number, and serial number. Safety markings, lights, and flags, are especially important for this piece of equipment, as it usually travels well ahead of the rest of the construction operations. The bristles on the sweeper should be checked to ensure that they are in good condition, and the width of the brush should be checked for evenness. The rotary and hydraulic lift controls should all be fully functional.

**An example of a rotary broom**

An asphalt distributor, arguably the most complex piece of equipment used for seal coat construction, is a truck-mounted, insulated tank with a number of special attachments. The asphalt distributor is composed of an asphalt tank, a heating system, a circulating and pumping system, filterscreens, a spray bar and nozzles, a hand sprayer, and controls and gauges. Each component must be thoroughly inspected, and the inspector should review all the procedures for doing so.

The aggregate spreader, also known as the "spreader box," spreads aggregate evenly over the layer of asphalt applied by the asphalt distributor. It consists of several major components that require inspection: truck hitch, receiving hopper, belt conveyors, spreading hopper, discharge gates, and discharge roller.

Haul trucks are used to transport and deposit the aggregate in the spreader. They are usually end-dump, tandem-axle or single axle trucks. The size of the truck bed should be noted, as well as the condition of the truck in general. Every truck should have a hitch compatible with the one on the aggregate spreader; the tailgate and hoist of the truck must also be inspected and approved. The haul trucks are required to have a unique identifying number to allow the inspector to easily recognize each truck.


**A pneumatic roller**

The rollers orient the aggregate in its flattest dimension and seat it firmly into the binder. For seal coats and surface treatments, TxDOT recommends a pneumatic roller to avoid crushing the aggregate. The identifying data should be recorded by the inspector, as well as the weight of the rollers. The contact pressure exerted by each tire must be calculated, and the inspector should ensure that each tire is inflated so that there is no more than 5 psi variation between them. The number of tires, area of coverage, and several other factors, such as the amount of wheel wobble, must meet specifications.

Front-end loaders move aggregate from the stockpile to the haul truck. The inspector should check the condition of the machine visually and record its identifying information. There are no particular components that require inspection; rather, the overall condition must be acceptable.

A contractor will sometimes set up a heater and storage unit for a large project. This unit is filled with asphalt, which is then pumped into a transporter or directly into an asphalt distributor. There is no standard configuration for this piece of equipment, and it may not even have identifying data if it has been manufactured by the contractor. The person operating the heater and storage unit must be aware of the flash point, or the temperature at which ignition could occur, of the binder in the unit. The inspector should check the storage tank for cleanliness and ensure that there is a continuous-reading thermometer on the tank and a way to adjust the burner on the heater. The entire unit should be inspected for safety.

## Chapter 6: Seal Coat/Surface Treatment Application Process

This chapter covers the sequence of events that occur during the application of a full-width seal coat, a strip or spot seal, and a surface treatment application. During this process, it is essential that the three inspectors assigned to the project work as an efficient and alert team.

During application, weather conditions must be thoroughly monitored. Construction should begin only if the temperature, humidity, wind, and rain conditions are suitable. Traffic control techniques must be followed according to the project plans or as specified in the Texas Manual on Uniform Traffic Control Devices (TMUTCD). The traffic control devices commonly used include signs, cones, flaggers, pilot vehicles, and arrow boards. Proper traffic control is of the utmost importance, as it directly impacts safety for the road users as well as the construction crew.

Before construction begins, raised pavement markers may need to be removed. A motor grader, front-end loader, or other acceptable method may be used. The best time of day to remove raised pavement markers is the morning when temperatures are cooler. Next, the pavement must be cleaned and swept. This step must be performed at the correct time: before application begins, but not too far in advance. Any vegetation and soil on the edge of the pavement should be removed at this time as well. After the pavement is cleaned, temporary flexible-reflective roadway marker tabs can be placed to designate lane lines according to the traffic control plans.

Next, the rock lands must be set. A rock land is the area covered by one preset size truckload of aggregate at the desired aggregate application rate. If the truck is empty when it reaches the marker at the end of the rock land, the aggregate application rate has been followed correctly.

Once the rock lands have been set, the asphalt shots may be set as well. An asphalt shot should equal the length of a predetermined number of full rock lands. The asphalt application rate in the plans is just an estimate and should not replace good engineering judgment. When setting the asphalt shot, the capacity of the distributor must be taken into consideration. The distributor should never be completely emptied by an asphalt shot, especially if emulsions are used as they tend to foam easily. The asphalt application should not begin until the haul trucks are loaded with enough aggregate to cover the shot and are placed behind the aggregate spreader box. The production rates of the asphalt distributors, spreader, and rollers must all be equally matched.

**Pilot vehicle guides traffic through construction site.**

The loader operation is an essential component of a successful seal coat application; it is often overlooked, however, because it is somewhat removed from the main activity of a project. The inspector must check the loader operation activity early and often to ensure that the operator is penetrating the stockpile deeply enough and close enough to the bottom that a representative scoop of aggregate is taken with each bucket. Contamination must be watched for, and the inspector should also make sure the operator is keeping the equipment off the aggregate to avoid degradation. The operator should fill the truck to its specified level each time so that the contractor will be paid correctly and the aggregate is applied at the correct rate. Finally, inspectors must look out for excessive dust problems and correct them with a light sprinkling of water.

Before the asphalt can be shot, many checks must be made. First the distributor must be prepared and the nozzles should be blown out to ensure that none of them are clogged. Then the spray bar height, paper joints, all equipment, and transverse alignment of the distributor must be inspected. Once these checks are performed, the application of the asphalt may begin.

Before and after each load of asphalt is sprayed, the distributor should be strapped. "Strapping" means using a calibrated measuring stick to measure the asphalt in the tank. Strapping allows the contractor to be paid correctly and the inspector to determine the average asphalt application rate for each shot. The application rate can be adjusted from one shot to the next if strapping is performed between each shot.

**Course attendees look at an asphalt distributor in Fort Worth, TX.**

Before the asphalt distributor begins shooting the binder, the aggregate spreader and all other equipment should be in position so that the rock can be placed immediately after the asphalt. A useful tip is to apply a short test strip on bare pavement to visually check for uniform aggregate spread before placing the rock on asphalt. As the aggregate is being spread over the asphalt, the inspector should watch closely to be sure that a thin and uniform “curtain” of aggregate is dropping through the spreader gates. The inspector should check behind the spreader as well to see if the pavement is getting contaminated or if there is any aggregate streaking. If the spreader or haul trucks are picking up any asphalt as they move across the new surface, this problem must be corrected immediately.

As for timing the aggregate application, the general rule of thumb is that it should be placed immediately after the asphalt is shot, as early placement maximizes embedment. Therefore, the spreader should follow very closely behind the distributor. Rolling should occur immediately after the aggregate has been laid with one exception: if an emulsion is used, the inspector should allow the emulsion to break before rolling to keep the roller tires clean.

This chapter also covers the following application procedures: patching and hand work, intersections and irregular shapes, brooming the excess aggregate, opening the road to traffic, placing temporary or permanent pavement markings, placing raised pavement markers, and cleaning up the worksite.

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### Seal Coat Planning and Design, MNT 703

The Seal Coat Planning and Design course is intended to provide engineering guidelines for planning, designing, and constructing seal coats. The specific topics that this course deals with are as follows: the need for a comprehensive consistent pavement preservation strategy; roadway selection criteria; material selection specification and test requirements; determining the proper seal coat or surface treatment for each project; traffic volume effects on seal coat projects; communication and coordination requirements during planning and application; and how to handle customer complaints. The first two chapters cover the same material as the first two chapters in the Seal Coat Inspection and Applications course; therefore the summary of this course will begin with the third chapter.

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#### Chapter 3: Guidelines for Treatment Selection

Chapter 3 covers the roadway factors that affect the decision of whether or not to use a seal coat, the type of surface defects that can be mitigated by seal coats, the effect of traffic volume on a typical treatment, the various types of seal coats and surface treatments, and the Modified Kearby Design Method.

The main factors that often affect the decision to use a seal coat on a particular roadway include the condition of the existing pavement, the types of defects the pavement exhibits and the efficiency of the treatment at addressing these defects, the cost of the seal coat in comparison to other treatments, the traffic volume, the percentage of truck traffic, and the repairs that would be needed prior to placing the seal.

The structural adequacy of the existing pavement is a major factor affecting whether or not a seal coat should be used. Seal coats can only correct minor surface deficiencies, such as cracks less than 1/8 of an inch, raveling, and a lack of skid resistance. With the right design, seal coats may be able to treat bleeding, although they are usually not recommended for that type of distress.

Seal coats can be applied to roads with all traffic volumes, although low volume roads are usually the most common recipients of this treatment. On a high-traffic volume road (ADT>10,000), short-term aggregate loss, vehicular damage from loose asphalt, flushing, increased tire noise, and extended traffic control during construction may occur.

**Attendees listen to a lecture at the Fort Worth course.**

Short-term aggregate loss can take place a few hours or days after construction and may be due to inadequate amounts of binder, inadequate embedment, or cold temperature applications. Vehicular damage can be minimized by allowing only slow-moving traffic on a new seal coat, and tire noise can be mitigated by applying a second application of the seal coat using smaller aggregate for the top layer. Using a modified binder may allow traffic to travel without restriction over a new seal coat much sooner than if an emulsion is used.

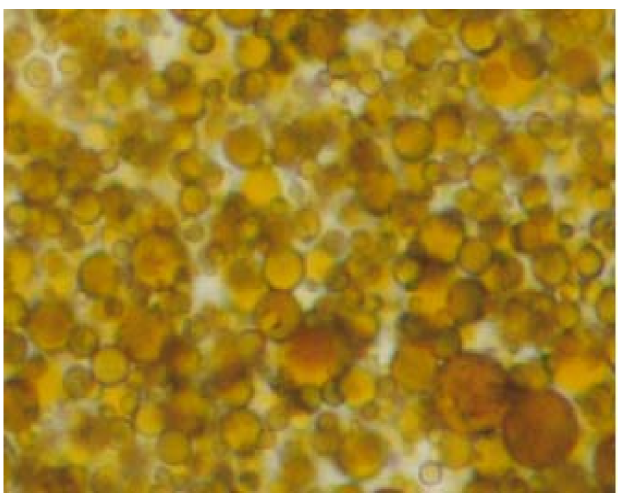
Strip or spot sealing is a maintenance treatment used to address longitudinal or transverse cracking, early signs of alligator or block cracking, flushing, low skid resistance, and segregated spots in asphalt concrete. All of these defects must be addressed immediately before they become too problematic to correct with minor maintenance. Surface treatments are seal coats that are placed on a prepared base rather than an existing pavement. Fog seals consist of a light application of asphalt, usually emulsion, over an asphalt concrete surface. This treatment is often used over a new seal coat to prevent chip loss.

The modified Kearby design method is an altered version of the original Kearby method recommended to TxDOT by the Texas Transportation Institute in 1981. This modified method is the most commonly used by TxDOT today. To use this design method, three laboratory tests are required: the Dry Loose Unit Weight, Bulk Specific Gravity, and Board Test. Although initial binder and aggregate application rates can be determined using the Kearby design method, good engineering judgment should always be followed; often, field conditions require the adjustment of both binder and aggregate rates.

## Chapter 4: Material Selection and Plan Preparation

This chapter focuses on the process of communication and coordination between personnel during a seal coat project, the properties and specifications of various types of binders and aggregates to determine proper selection for each seal coat project, and ways to plan and contract a seal coat project.

Once a roadway has been selected for a seal coat treatment, the project design office, the area engineer, the maintenance supervisor, and any other district personnel involved in the project must establish a method of communication and coordination. Then they will be able to discuss important issues such as lessons learned from previous seal coat applications, which materials to use, and whether repairs and patching should be performed by state force or contract.



**Emulsified asphalt (greatly magnified)**

There are three types of binders commonly used for seal coats: asphalt cement, cutback asphalt, and emulsified asphalt. Each form takes a slightly different approach to liquefying the asphalt and enabling it to be applied in spray form from an asphalt distributor. Asphalt cement is heated at a very high temperature until it becomes fluid, while cutback asphalt uses a petroleum solvent such as naphtha or kerosene. Emulsified asphalt is asphalt that has been broken into minute particles and dispersed in water with an emulsifier. When the emulsified asphalt breaks, the tiny droplets of asphalt are released.

The most important requirements in the specifications for asphalt cements are the viscosity, penetration, and aged viscosity. When using a cutback asphalt, TxDOT generally uses either the rapid curing (RC) or medium curing (MC) varieties. RC cutbacks cure faster because the solvent used, gasoline-naphtha, is more volatile than the kerosene solvent found in MC cutbacks. Asphalt emulsions are often used because they can be applied at a much lower temperature than asphalt cement. An emulsion can either be anionic, cationic, and non-ionic, though only the first two are used for surface treatments and seal coats. When using an emulsion, pre-coated aggregates should not be used because the coating inhibits the chemical break, absorption, and adhesion of the emulsion to the stones.

**Aggregate breakdown during coring operation**

In a seal coat or surface treatment, the aggregate serves to resist abrasion from moving wheels and transfers wheel loads to the lower layers of the pavement. Aggregate also provides skid resistance, light-reflecting qualities, and a difference in texture or color to demarcate shoulders or other distinct areas of the road. Aggregates can be either natural (such as crushed gravel, crushed stone, and natural limestone rock asphalt) or synthetic (including light weight aggregate made of shale, clay, or slate, and crushed slag made as a by-product of steel production).

The characteristics of aggregates that affect seal coat performance are maximum particle size and gradation, cleanliness, and shape, which includes the Average Least Dimension (ALD). ALD is the overall average of the smallest dimensions of the stone particles and controls the quantity of cover stone and asphalt binder that should be applied. Other aggregate factors affecting performance include toughness, or resistance to abrasion and degradation, aggregate absorption (only applies to uncoated aggregate), and precoated aggregate. Aggregates are precoated with asphalt binder to maximize adhesion, reduce the accumulation of dust on the aggregate surface, maximize aggregate absorption, and increase color contrast between the striping and the road surface.

Other than the above characteristics, aggregates are selected for their ability to meet the frictional demands of the roadway and their relative costs.

When planning a seal coat, one of the first priorities should be determining the quantity of the materials needed. Before the quantity can be set, the area of the roadway to be covered must be calculated. Though the actual binder and aggregate application rates should be based on a design procedure after the materials are delivered but before the start of construction, it is only necessary to estimate these rates during the planning stage. Estimates should be based on site-specific conditions and local experience.

Plans for seal coat contracts should consist of at least the following: a title sheet, general notes, specification data, a summary of quantities, project location and limits, and standard sheets. Before construction begins, costs should be estimated using the Construction Division's (CST) monthly report for construction and maintenance contracts.

## Chapter 5: Public Perception and Complaints

The final chapter in the Seal Coat Planning and Design course covers how to handle customer complaints that may occur during or after seal coat construction. Anytime a maintenance professional must handle a complaint, he or she should do so in a courteous, professional, and timely manner.

Most complaints about seal coats are due to vehicle damage from loose aggregate or asphalt sticking to vehicles. Complaints related to either of these problems should be directed to the contractor during contract work and to the local TxDOT office once the work is complete. If state forces are handling the seal coat work, each complaint should be investigated by district personnel.

Because seal coats and surface treatments are used extensively, it is important that the public understand how effective they are at preserving the road system. Sometimes complaints are made about seal coats in general, as the public often dislikes the tire noise or loose aggregate sometimes seen with this treatment, or they simply consider it to be inferior to an asphalt concrete overlay. A complaint of this nature can actually be seen as an opportunity to educate the public and improve customer satisfaction. Coordinating with the district's Public Information Office is often helpful when dealing with complaints and attempting to educate the district's customers.

**Contributors to the Austin Seal Coat courses: (left to right) Tammy Sims, P.E., TxDOT; Joe Graff, P.E., TxDOT (retired); Cindy Estakhri, P.E., TTI; Gerald Peterson, P.E., TxDOT, and Dr. Yetkin Yildirim, P.E., TPPC**

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## TPPC Board of Directors



## Our Mission

The mission of the TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

## Contact Us

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## Past and Upcoming Events

As part of our continuing mission to advance the field of pavement preservation, the Texas Pavement Preservation Center is offering training courses on seal coats, the Texan term for chip seals. The courses serve two main groups: engineers and inspectors. The course designed for inspectors, entitled “Seal Coat Inspection and Applications,” focuses on proper inspection methods and the equipment used during chip seal construction. The other, “Seal Coat Planning and Design,” instructs engineers on planning, designing, and constructing chip seals. The purpose of both courses is to increase the awareness and understanding of pavement preservation by providing instruction on a common preservative maintenance treatment.

Both sections of the course are approximately 8 hours in length and offer attendees 0.8 Continuing Education Units. To receive a certificate of completion for the course, all attendees must score a passing grade on a series of quizzes over the material covered.

The first four rounds of Seal Coat courses were held in Fort Worth February 27 and 28, Austin March 18 and 19, Lubbock April 15 and 16, 2008 and San Angelo November 6 and 7. Additional courses are scheduled to begin in the spring of 2009.

The TPPC and TxDOT are also in the process of developing training courses on microsurfacing, another common pavement preservation treatment. This course will teach attendees the concepts behind the current best practices for microsurfacing in the industry.

For more information on the Seal Coat and/or Microsurfacing courses, please contact Dr. Yetkin Yildirim, P.E. at Yetkin@mail.utexas.edu or (512) 232-3084.

## Pavement Preservation (PP) Treatment Selection

As part of our continuing mission to improve pavement preservation practices and disseminate important PP concepts, the TPPC is currently conducting a literature review centering on the topic of pavement preservation treatment selection. In this issue, we provide a brief summary of the information included in this literature review. Topics covered include: the advantages and attributes of a well-organized pavement management system (PMS), PMS development, parameters that should guide treatment selection, methods of measuring pavement distress and roadway characteristics, and strategies for pavement assessment, data analysis and treatment selection.

### Pavement Management Systems (PMS)

A pavement management system, or PMS, describes the approach that an agency takes to road maintenance. The American Association of State Highway and Transportation Officials (AASHTO) defines a PMS as "a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a period of time."

The effectiveness of a pavement maintenance organization is generally determined by the PMS in place. Therefore, PMS development should be a very careful and thought-out process. During the PMS development process, the agency must establish program guidelines, an organized approach to identifying the proper locations and times for PP treatment placement, a method of determining feasible treatments, a logical approach to final treatment selection, implementation procedures, and a system for program assessment. Careful planning and informed decision-making can provide the road agency with one of the most important tools for successful pavement management: an effective PMS.

### Factors to Consider

Before a pavement preservation project or treatment can be selected, the agency must learn as much about the roadway in question as possible. The existing pavement must be studied, tested, and analyzed, and all relevant information related to the roadway must be considered:

### Existing Pavement Condition

The age of the existing pavement and its material makeup, structural condition, and current distress must be evaluated or determined for an agency to make an informed treatment selection. Pavement condition is defined by the amount and type of distress exhibited, riding comfort, load-carrying capacity, safety, and appearance. The main types of distresses that should be measured are cracking (both type and extent), raveling, oxidation/weathering, bleeding, flushing, rutting, shoving, patching, loss of friction/polished aggregate, and roughness.

Identifying the cause, type, and extent of the pavement distress should be the agency's first priority. Often, worries over cost and financial constraints obscure the project's main goal, which is to achieve effective results. In order for the agency to decide if a pavement is a good candidate for preservation efforts and, if so, what treatments would be the most beneficial, any problems that the pavement has must be thoroughly understood.

One type of pavement distress that must be considered when selecting a treatment is cracking. Cracks must be investigated further; the type and extent of an exhibited crack must be identified. Agencies commonly qualify cracking by identifying the type, such as longitudinal cracking, fatigue or alligator cracking, transverse cracking, edge cracks, thermal cracks, shrinkage cracks, and sealed or unsealed cracks, and the extent, which takes crack width and severity into account.

Fatigue Cracking

The pavement's surface condition must be assessed as well. Surface distresses that should be evaluated prior to treatment selection include raveling, oxidation or weathering, bleeding, flushing, rutting, shoving, patching, polished aggregate or loss of friction, roughness, and ride quality. Usually these distresses are further categorized by severity into low, moderate, and high levels. Clear definitions for each severity level of every condition must be developed to reduce variations between one pavement surveyor's evaluation and another's.

### Estimated Service Life of the Treatment

Along with the existing pavement conditions, the estimated service life of potential treatments must be taken into account if thoughtful preservation decisions are to be made. Decisions must be based on the estimated effect of the treatment on the pavement's performance life, not on the life and performance of the treatment itself.

Although performance life is dependent on a variety of factors, agencies must calculate the number of years a treatment can reasonably be expected to last. If there is no reason to believe that a treatment will extend the life or improve the performance of the pavement, it should be rejected.

Rut depth measurement

## Traffic Conditions

Traffic conditions, such as volume, composition, and patterns of movement, are key parameters to consider when selecting appropriate treatments. The amount of traffic that a road is normally subjected to can greatly affect which treatment should be used. Some treatments are only suitable for low or moderate traffic levels, while others are excellent for heavy amounts of traffic. Traffic loading is one of the most important factors to consider after pavement distress, as it is the main source of pavement wear. Likewise, understanding the type of traffic that will be using the road is crucial to understanding the stress a pavement will undergo. For example, a road that sees a high volume of trucks will require a different treatment than a neighborhood street. Considering the road's classification then becomes essential to treatment selection. The way in which a road is used impacts the pavement surface significantly and makes some treatments more appropriate than others. For instance, a road can be identified as an interstate or non-interstate; as urban or rural.

Other key factors relating to traffic conditions include stop points and turning points. These specific areas of the pavement can be subject to increased stress, which may require a different type of treatment than other areas. The amount of roadway curvature can be an important circumstance also. The durability of the selected treatment must be appropriate for the traffic volume, the type of traffic, and how the traffic normally moves on the roadway.

Traffic volume can affect treatment selection for an additional reason: different types of treatments take different amounts of time to apply and cure. The amount of traffic disruption that will occur for each feasible treatment, based on traffic volume and curing time, must be weighed. Agencies must ensure that the application and curing times of potential treatments are appropriate for the roadway's traffic levels.

## Noise Requirements and Aesthetic Preferences

Further considerations when selecting a PP treatment include roadway location, noise requirements, and aesthetic preferences. The amount of traffic, the posted speed limit, and the location of the roadway can seriously increase or reduce the need for treatments with low noise levels. Some treatments are designed for a quiet ride, while others are notoriously loud. Including noise levels in treatment selection decisions can increase customer satisfaction.

Customer satisfaction is also related to aesthetic aspects of the roadway, such as dust levels during construction or the general appearance of the pavement. Customers obviously prefer an attractive road, especially in certain locales, such as a highly visible street in the town square.

## Climate Conditions

Climatic conditions should also guide pavement preservation treatment selection. The type of weather a pavement will have to withstand will influence which treatments can and cannot be used. Obviously, treatments used in a desert, valley, coastal, or mountain region would all vary. Other environmental conditions, such as the amount of acid rainfall, can impact treatment selection, as well. Additionally, areas that see significant amounts of snowfall can have pavement problems associated with the level of snow plow use.

Along with average weather conditions, the best time of year and weather conditions for the placement of a specific treatment must be considered. Every treatment has limitations as to when they can be applied most effectively. Some general limitations are related to optimal placement times and weather conditions. For instance, some treatments are best applied at night due to heavy traffic volume or other factors. A need for nighttime application can affect what time of year the treatment must be applied, as temperatures drop at night. Applications requiring warm temperatures must therefore be placed during a season that rarely experiences chilly nights. Other than seasonal constraints, timing is highly important, as roadways continue to deteriorate until a treatment is placed. Agencies must ensure that they are able to perform treatments while the pavement distress is still light enough to be relieved by pavement preservation techniques. Furthermore, treatments must not be applied too early in a pavement's life; otherwise, they will not be cost-effective. Precise timing of treatments is essential to good pavement performance.

## Financial and Construction Data

Timing is often directly related to the financial aspects of the decision process. A key component of treatment selection is the cost of the treatment. Obviously, each project depends heavily on the availability of funding. If the best treatment exceeds the agency's budget, it cannot be used, regardless of how well it fits with the other factors involved. Perhaps even more crucial than the initial cost of the treatment is the treatment's cost-effectiveness.

Cost-effectiveness is defined as the relationship between the long-term cost of a pavement maintenance treatment over a given evaluation period and the improvement in serviceability of the pavement. Therefore, agencies should consider not just the initial cost, but whether a treatment will be worth its cost in the long run. Pavement preservation is designed to provide the most cost-effective methods of dealing with pavement deterioration, so the lifetime cost of a treatment is naturally a matter of concern to roadway agencies.

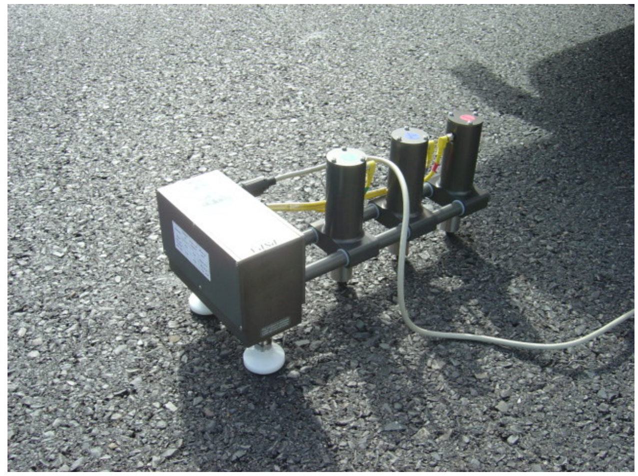
Even if sufficient funding is available, an otherwise acceptable treatment may have to be rejected due to construction constraints. Therefore, agencies must weigh the availability of proper materials and qualified contractors into their decisions. Some treatments require special materials or application skills, which may force agencies to choose an alternate treatment.

These are just a few of the factors that must be considered when selecting an appropriate pavement preservation treatment. To make informed decisions, the age of the existing pavement and long-term road plans must be considered. Road agencies must also consider the availability of skilled construction crews and materials when considering how to apply the right treatment to the right road at the right time. Treatment selection must be based on multiple, and often interdependent, factors. It is therefore crucial that the agency identify and prioritize the parameters that will be used to come to a final treatment decision.

### Data Measurement and Collection

For agencies to make proper treatment selection decisions, all of the parameters of those decisions must be accurately measured and evaluated. Researchers are constantly attempting to develop new, simpler, and more accurate methods of measuring these factors. In addition to evaluation of individual factors, many agencies also attempt to synthesize the pavement distress data into a general picture of pavement condition. The following will be a brief overview of the methods mentioned in the existing literature.

One of the most common techniques for pavement data collection is the utilization of a condition survey. A condition survey occurs when a maintenance team attempts to collect data on all the individual distresses a road is experiencing to form an impression of the condition of the pavement as a whole. There are a myriad of ways to conduct a condition survey, including manual, automated, high-speed lane pass, low-speed shoulder pass, and photographic.



Portable Seismic Pavement Analyzer Equipment

Usual methods of crack evaluation include visual inspection, coring, employing a falling weight deflectometer (FWD), using ground-penetrating radar (GPR), and using ultrasonic equipment. "Evaluation of Top-Down Cracks in Asphalt Pavements by Using a Self-Calibrating Ultrasonic Technique" by Khazanovich, et al. describes a study by the Colorado DOT that tested the accuracy of visual observation for determining crack depth and found that visual measurements cannot be counted on to provide correct results.

Coring is not entirely accurate either, and because coring is destructive, the common practice is to core only a sample of the cracks in a pavement segment, leaving many cracks unmeasured. FWD's are often too sensitive to irrelevant parameters to detect shallow cracks, and GPR's give results that require expertise to read, which limits their usage to experts. Khazanovich, et al. recommend using ultrasonic equipment with a dry point contact (DPC) transducer, based on the results of an MnROAD research study.

Temperature measurements for Falling Weight Deflectometer

As Baladi, et al. explain in "Pavement Condition Index—Remaining Service Life," roughness is usually measured using a response-type measuring system or a profilometer. Typically, roughness will be expressed in mm/km, in/mile, counts/unit length, and so on. Road roughness indicates ride quality and the tangible benefits that road users gain from preservation efforts. Therefore, roughness measurements are often used to evaluate the general condition of a road. The International Roughness Index (IRI) developed in 1982 provides a common quantitative basis for the comparison and calibration of roughness measurement results and is used extensively by road agencies.


Ground Penetrating Radar Equipment

Once individual pavement distresses are evaluated, many agencies choose to combine the distresses into one or several parameters. The terms "distress index" and "condition index" are often used. An example of a condition index is the pavement condition index, or PCI. PCI, as described in Hajek and Phang's "Prioritization and Optimization of Pavement Preservation Treatments," is based on a 0 to 100 scale and utilizes measurements of ride quality and the severity of 15 different pavement surface distresses. There are dozens of other condition indices commonly used, as these indices simplify the pavement distress data and put it in quantitative terms. Much of the literature warns that condition indices can introduce problems, however, such as those caused by a lack of consideration for the rate of deterioration of the pavement that is inherent in many of these indices.

According to Balmer, et al. in "Pavement Friction Measurements and Vehicle Control Reparations for Nontangent Road Sections," a common way of measuring friction is with a small trailer-like device that can be towed with a pickup truck called a Mu-meter. Balmer et al.'s research found that Mu-meters are not effective at evaluating friction on a curve; however, the authors suggest using a two-wheeled trailer that has been specially instrumented to measure both the dynamic vertical test-wheel load and the longitudinal drag wheel force instead.

The remaining service life, or RSL, is often used when selecting a PP treatment. In "Expert Project Recommendation Procedure for Arizona Department of Transportation's Pavement Management System," Flintsch and Zaniewski define RSL as an estimate of the number of years left before an existing pavement will need a preservation treatment, or the minimum number of years when either cracking or roughness reaches the threshold value. Calculation of the RSL is achieved using a performance prediction equation and a trigger point for each condition indicator. The literature describes RSL as a very important tool for determining the proper time to place a PP treatment.

The cost-effectiveness of the available treatments is often of critical concern to agencies. According to Hicks, et al. in "Selecting a Preventive Maintenance Treatment for Flexible Pavements," the first step in determining cost-effectiveness is identifying the expected life of the treatment in years and finding local cost data. Then, the equivalent annual cost (EAC) can be found from dividing the unit cost by the number of years the treatment is expected to last. EAC is a very simple method of determining cost-effectiveness, and many others exist that include other figures into the cost estimate. For instance, Tarte, in the 2006 International Asphalt Conference presentation "Investment Decisions for Road Pavement Projects and Networks," insists that the user costs, which include vehicle running costs, cost of time spent during travel, costs incurred due to accidents, and cost of other personal factors, like driver comfort and convenience, be included in all calculations of cost-effectiveness.

Traffic volume is most commonly measured using the Annual Average Daily Traffic (AADT) and Average Daily Traffic (ADT) counts. Garber and Hoel describe AADT as an average of 24-hour counts taken continuously throughout the year and ADT as an average of 24-hour counts taken on multiple days, but not totaling a year, in their book, *Traffic and Highway Engineering*. Both AADT and ADT require traffic to be counted, which can be done automatically or manually. Manual traffic counting must be done by a person with a counting device, such as a manual electronic counter. Automatic counting usually uses surface detectors, like pneumatic tubes or subsurface detectors, which are usually either electric or magnetic contact devices.

Traffic composition is most often measured by the Annual Average Daily Truck Traffic (AADTT). As Huang's *Pavement Analysis and Design* explains, AADTT can be represented as a percentage of the ADT or as a regular value. If no information on AADTT exists, it can be estimated based on the class of the roadway in question.

Along with current road conditions, Jahren, et al. recommend collecting historical pavement data in "Quantitative Guidelines for Use of Thin Maintenance Surfaces." This data can be found by examining records stored in the agency's database with information on a pavement's historical background, relevant design features, past problems, etc. The resident maintenance engineer should be consulted, as well, to ensure that any seasonal or past problems affecting a pavement segment are taken into consideration, as these issues may not be readily apparent when evaluating the pavement condition.

## Data Analysis and Treatment Selection

Deciding which factors to consider in treatment selection and collecting data on these factors are only the first steps in choosing a proper pavement preservation treatment. All the data gathered about a pavement must then be translated into an appropriate treatment option, which may be the most difficult step of the selection process. At this point, agencies usually have a number of considerations to factor into their decision, and seeing the best treatment just from looking at the collected data can be nearly impossible. Therefore, a system to organize the information, identify the key problems, and suggest workable solutions is usually adopted.

In an attempt to minimize the complexity of this process, agencies often adopt methodologies that preclude the need to make challenging project decisions. They often depend on regularly scheduled maintenance, or "worst first" reconstruction projects. But these practices do not qualify as pavement preservation systems. Regularly scheduled maintenance activities may preserve pavements, but they can be costly and inefficient. Obviously some pavements will need treatments more or less frequently than others, and maintenance schedules are not designed to address unforeseen problems. Atypical environmental conditions, poor construction practices, or sudden changes in traffic volume cannot be accounted for when treatments are placed according to a set schedule.

Fixing the worst roads first is antithetical to pavement preservation, which requires treating roads in good condition to halt deterioration. If a PMS focuses only on poor roads, the system is not a pavement preservation program by definition; "worst first" practices are the mark of pavement reconstruction programs. What pavement preservation offers is the chance to extend the life of existing roads; a much more challenging, but also more cost-effective alternative. Instead of letting roads degrade until they are in need of repair, a pavement management system provides an agency with the means to keep their roads in working condition longer.

The best preservation programs follow cause-based strategies. A cause-based strategy focuses on fixing or eliminating the cause of pavement problems. Instead of treating the symptoms of a pavement in serious distress, this strategy seeks to root out the source of current or future distress. A cause-triggered strategy obviously requires more data collection and more analysis to achieve than a schedule-based or "worst-first" strategy. Cause-based systems allow agencies to end the sources of distress, thereby effectively preserving the pavement in question.

Forming an effective framework is fundamental to a program's success, as appropriate treatment selection for each project is absolutely imperative. A database is a tool that can be used to organize all pavement-related information and clearly defined decision criteria. Having such a framework will help agencies to identify a range of possible treatments. But in order to choose the best, most cost-effective treatment, the agency must also develop analysis procedures. Analysis procedures should compare each possible treatment, using cost-effectiveness and any other important criterion that could affect the success of the selection in a decision matrix. Agencies must also have clearly detailed implementation procedures. There are many decisions to be made, such as the selection of a contractor, whether or not to use a warranty, and which inspection procedures to use during construction. Quality control and quality assurance procedures must be chosen as well. Every step of a pavement preservation program should be organized and systematic. A standard procedure for each aspect of treatment selection will ensure high quality throughout.

Finally, agencies should attempt to analyze the effectiveness of their selection systems. Program assessment can be achieved through the inclusion of a feedback mechanism, which will allow agencies to quickly identify and correct any problems. Road agencies must be able to understand if the PMS in place is meeting its specified goals; otherwise, the current strategy must either be modified or replaced.

An effective pavement management system should not be considered infallible, however, as every system has its limitations. A PMS will rarely produce a choice that is clearly superior, but it will allow for the implications of certain decisions to be understood. Furthermore, the results of a PMS do not retain their validity after a certain period of time. The results will no longer be accurate if they are not acted upon swiftly. Therefore, a PMS should be viewed as a decision support tool, and not as the final word on pavement decisions. Some sources even recommend using an alternative to a PMS, such as a Level-of-Service (LOS) program. An LOS assesses a variety of different assets and measures several types of parameters, whereas a PMS focuses mainly on the condition of pavement assets. Agencies must decide on their own which type of system works best for them and then remain alert to any problems or limitations involved with their system.

## Summary

Although proper pavement maintenance treatments are oftentimes challenging to select, a well-developed pavement management system can alleviate many of the difficulties involved. A good PMS must have clearly defined goals, identify which factors are important considerations for a project, determine the relative importance of each of these factors, describe how to obtain the necessary data, and then provide the proper tools and methods for the ultimate selection of a treatment. Agencies may be tempted to avoid the complicated process of developing a PMS, but the success of their pavement preservation programs depends upon their doing so. Pavement preservation requires an accuracy of selection and timing that cannot be achieved through arbitrary decisions. Preservation programs must rely on objective methods and systematic approaches to treatment selection, not on past experience, anecdotal information, or even expert opinion. An effective PMS produces precise treatment selections and makes for a successful pavement preservation program overall.

THE UNIVERSITY OF TEXAS AT AUSTIN + COCKRELL SCHOOL OF ENGINEERING

TEXAS PAVEMENT PRESERVATION CENTER

TxDOT

Newsletter

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## TPPC Board of Directors



## Our Mission

The mission of the TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

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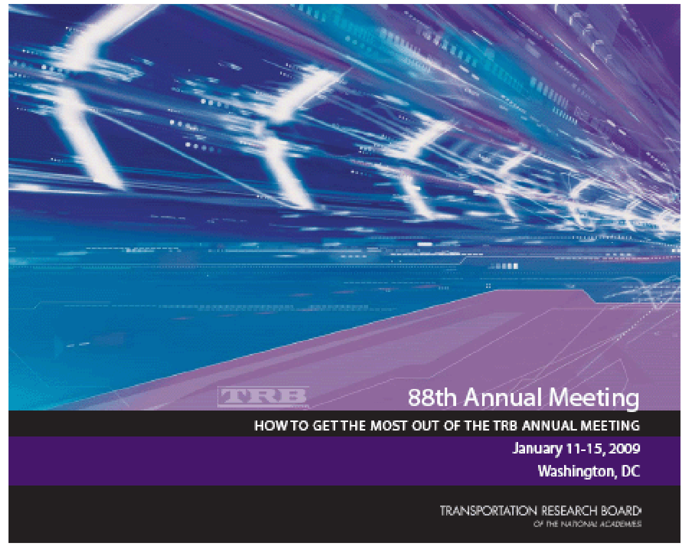


## Past and Upcoming Events

### TRB 88th Annual Meeting

The Transportation Research Board is a division of the National Research Council, which serves as an independent adviser to the federal government and others on scientific and technical questions of national importance. The Transportation Research Board's 88th Annual Meeting assembled more than 10,000 transportation professionals from around the world in Washington, DC on January 11-15, 2009. The program consisted of over 3,000 presentations in 600 sessions. Summaries of selected seminar papers related to pavement preservation are included in this issue.

### Scrub Seals

As part of our continuing mission to advance the field of pavement preservation, the Texas Pavement Preservation Center is including in this issue a brief overview of a temporary pavement treatment option used by TxDOT: scrub seals. Scrub seals, as a cost-effective alternative to seal coats, can provide a temporary fix for low volume roads.

### TPPC Seal Coat Training Courses

Seal Coat training courses will continue to be offered by the TPPC. The course designed for inspectors, entitled "Seal Coat Inspection and Applications," focused on proper inspection methods and the equipment used during chip seal construction. The other, "Seal Coat Planning and Design," instructed engineers on planning, designing, and constructing chip seals.

For more information on the Seal Coat courses, please contact Dr. Yetkin Yildirim, P.E. at yetkin@mail.utexas.edu or (512) 232-3084.

**TxDOT Experience with Scrub Seals** by Dianah Ascencio, TxDOT

Consistent procedures and processes used to preserve and extend the life of the roadway are the backbone of routine maintenance. But as construction and material costs rise, and maintenance dollars dwindle, the challenge of routinely maintaining Texas' roadways has burgeoned; forcing TxDOT to seek out less expensive, alternative solutions to highway preservation—particularly the rural farm to markets.

While maintenance offices across the state *are* thinking outside the box and formulating new techniques, in many instances they are returning to the old playbook and relying on trusted, yet improved, methods.

"We are adapting and doing new things on low volume roads. But in some cases, we're going back to old methods," said Tracy Cumby, Lubbock District maintenance administrator.

The scrub or squeegee seal method uses new and modified rubber emulsifiers to combat roadway deterioration and extend a roadway's life expectancy as cost effectively as possible. In the scrub sealing method, asphalt emulsion is squeegeed over the entire road surface, filling the cracks. Then, this emulsion is covered by sand, small aggregate. A drag broom may be used to further smooth the fine aggregate, or else rolled excess aggregate can be swept off the following day.

According to Cumby, this process improves the characteristics of the highway surface. "It may not be the smoothest ride, but it buys a little time before you have to come back in with a seal coat. And, it prevents you from having to do a costly total rehab."

A tire rubber modified surface sealer, which contains 10 percent tire rubber emulsion, is being used on a project in the Lubbock District's Crosby County to pre-treat a 12-mile section of FM 207.

"We're using the material to seal cracks and prevent moisture from getting into the base and doing any more damage before we come back this summer and seal coat the roadway," said David Barrera, Crosby County Maintenance supervisor.

Products like the one being used on FM 207 provide benefits that go beyond preserving the roadway.
"It's easier and safer to use," Barrera said. "The product arrives from the plant and goes down at ambient temperature. It doesn't require any additional heat."

The material's relatively quick curing time, within an hour to an hour and a half in the West Texas wind and heat, allows traffic to be put back on the roadway fairly quickly. Though this method is not nearly as effective as seal coating, it is a good alternative to the more costly processes, Cumby adds.

Preserving an aging transportation system continues to be increasingly difficult. Without the needed funds to totally rehabilitate roadways, maintenance sections are resorting to the less expensive scrub and fog seals, and seal coat alternatives. Perhaps not fixing the problem, but offering some relief and buying time. “Fewer maintenance dollars means we rethinking our operations,” explained Cumby. “Bottom-line is we need to work smarter, watch waste and adopt good practices even if we had plenty of money.”

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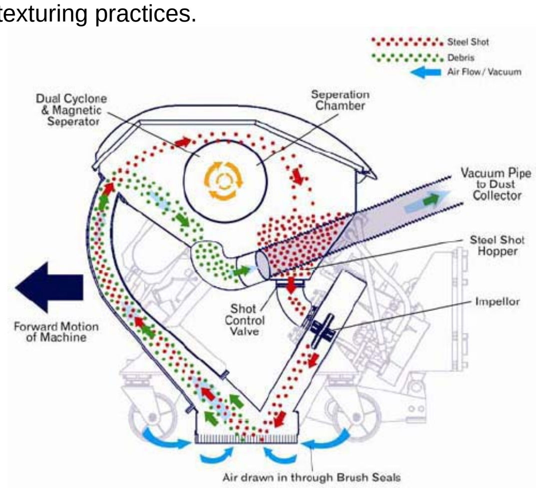
***TRB 86th Annual Meeting***
***Selected Pavement Preservation Papers***

**Life Cycle Cost Analysis of Surface Retexturing with Shotblasting as an Asphalt Pavement Preservation Tool** by Douglas D. Gransberg

In, Gransberg’s analysis, shotblasting is proposed as an economically viable and environmentally sustainable alternative to current surface retexturing practices. The shotblasting process involves a machine that propels abrasive particles onto the road surface to blast away contaminants, retexture a polished surface, and restore skid resistance. This technique is routinely used by major US airports to restore runway skid resistance, and the pavement life cycle cost analyses conducted in this study conclude that the same technique could be used effectively on public highways. Currently, pavement microtexture and macrotexture can only be restored by replacing the chip sealing and thin hot-mix asphalt overlays. The use of shotblasting technology proposes to retexture polished pavements, improving their micro- and macro- texture, without requiring the use of any asphaltic material or aggregate, and with minimal disruption for the traveling public. An agency that invests in this shotblasting technology would be able to improve both concrete and asphalt pavement skid resistance without the consumption of additional asphalt products, with minimal impact to the traveling public, and in weather too cold to permit traditional pavement retexturing practices.




**Typical Shotblasting Apparatus Process (TRB 09-0409 pg. 4)**

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**Comparing Hot Asphalt Cement and Emulsion Chip Seal Binder Performance Using Macrotexture Measurements, Qualitative Ratings, and Economic Analysis** by Douglas D. Gransberg

Roads with a poor pre-seal condition demonstrate an early loss of macrotexture and premature flushing after a re-seal. This study offers the first quantitative proof that, regardless of binder type, pre-seal conditions ultimately determine the post-seal performance of the pavement. These results suggest that the unpredictable results of chip seal application may have less to do with the skill of the worker and more to do with the variety of pre-existing pavement conditions. The study also demonstrated that, given equal existing pavement conditions, emulsion chip seals are more cost effective than hot asphalt cement chip seals, because emulsion chip seals are shown to lose their macrotexture at a slower rate.

**Southbound Lane Sand Circles on Highway 19 (TRB 09-0411 pg. 5)**

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**Chip seal maintenance: solutions for bleeding and flushed pavement surfaces** by William D. Lawson and Sanjaya Senadheera

Lawson and Senadheera present a range of maintenance solutions that address the problems of bleeding and flushed pavements. The summary of available treatment methods presented in this paper should be a useful resource to pavement agencies. Bleeding and flushed pavements are caused by the presence of inadequate voids between the aggregate particles, which causes the asphalt binder to rise above the surface of the chip seal aggregate. Bleeding pavement is an immediate maintenance concern, and can be alleviated by the application of aggregate of various gradations, cooling the pavement surface by applying water with or without additives, and removing the bleeding asphalt and completely rebuilding the pavement seal. On the other hand, flushed pavement does not require such emergency measures, although it still constitutes a safety risk due to the loss of pavement skid resistance. In the case of flushing, pavement can be retextured using a variety of methods, or a new textured surface can be installed over the flushed pavement.

**Applying Small-Size Aggregate to Treat a Bleeding Chip Seal (TRB 09-0659 pg. 9)**

**Development and implementation of network-level selection of pavement maintenance and rehabilitation strategy: Virginia practice** by Wu, Shekharan, Chowdhury, and Diefenderfer

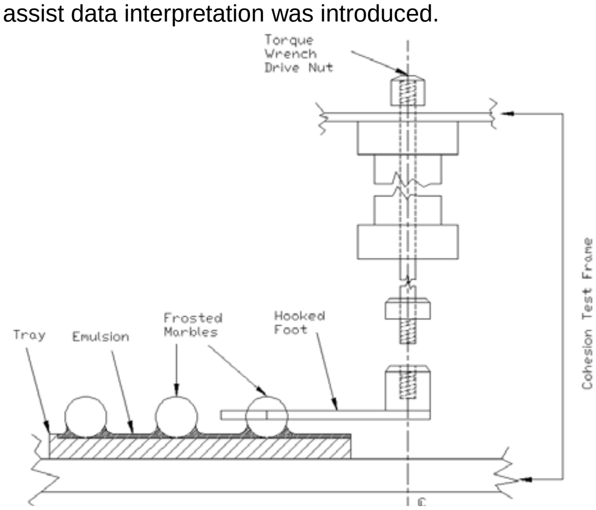
According to Wu, et. al, the planning methods of the Virginia Department of Transportation demonstrate the need for network-level pavement maintenance and rehabilitation planning. The decision matrices used by the agency have evolved over time to account for both network-level and project-level considerations in order to achieve a balance between the demands of local asset conditions, public opinion, and budgetary restrictions. The processes of network-level decision making developed from the use of composite condition index values to include distress-based decision matrices, as more distress data became available. As more data became available to the agency, including FWD data, traffic data, and surface age data, this data could be incorporated into maintenance considerations, resulting in more detailed treatment rules and a more accurate estimate of maintenance requirements. But rather than enlarging the already complex, existing distress-based decision matrices, this paper promotes the use of supplementary decision trees to enhance the flexibility and consistency of pavement maintenance planning methods.

**Development of distress guidelines and condition rating to improve network management in the province of Ontario** by Chamorro, Tighe, Ningyuan and Kazmierowski

New guidelines for the evaluation of pavement distresses at the network level for the Ministry of Transportation of Ontario are presented by Chamorro, et. al.: the MTO Pavement Distress Guidelines for Network Level Evaluations and the Distress Manifestation Index for Network Level (DMINL). These new guidelines were developed in consideration for their suitability to the automated/semi-automated pavement distress data collection technologies of the future. By analyzing distress data collected by automated technologies in a 2006 survey, this study formulates the guidelines that should govern the use of such collection technologies in the future to assure quality control.

**Chip and scrub seal binder evaluation by frosted marble aggregate retention test** by Isaac L. Howard, James Michael Hemsley Jr, Gaylon L. Baumgardner, and Walter S. Jordan, III

Howard, et. al. offer a detailed description of the *Frosted Marble Test (FMT);* a test that can be used to evaluate the curing of bituminous materials. The aggregate retention method of the FMT was developed for the Mississippi Department of Transportation, and this report includes the original Mississippi field data, original test methods, and the test results from the original protocol. Some problems with the FMT have been identified, and according to this research, certain protocols should be refined in order to make this test a major tool for bituminous material evaluation. According to this report, the FMT could be greatly improved if testing variability was addressed, a curing protocol was established, and a complimentary horizontal scale to assist data interpretation was introduced.




**Overall View of *FMT* Frame, Hooked Foot, and Tray (TRB 09-1662 pg. 9)**

**Georgia's evaluation of surface texture, interface characteristics, and smoothness profile of micromilled surface** by Lai, Bruce, Jared, Wu, and Hines

In their evaluation of surface texture profiles, Lai, et. al. propose the use of micromilling in the application of open-graded friction courses or Porous European Mixes (PEM) for road rehabilitation. Conventional rehabilitative milling practices require the placement of a dense-graded Stone Matrix Asphalt (SMA) layer before any new friction courses can be applied. By analyzing the research findings of a micromilling operation in conjunction with a PEM overlay in Georgia, this study demonstrates that the use of micromilling eliminates the need for SMA placement, and that Porous European Mixes (PEM) can be placed on top of micromilled surfaces without requiring a new surface mix layer. The estimated cost savings for this proposed method of micromilling is $58,000 per lane mile.

**Micromilling Drum (top) and Conventional Milling Drum (bottom) (TRB 09-1857 pg. 4)**

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**Automated Cracking Survey and Protocol Design** by Kelvin C.P. Wang, Zhiqiong Hou, and Weiguo Gong

Wang, et. al. describe the latest developments in pavement cracking survey technologies, with regard to data acquisition and interpretation. New developments discussed in this study include the use of laser based imaging and real-time, fully-automated analysis. This analysis is based on the data generated by the Automated Distress Analyzer (ADA), a program currently used to automatically identify crack locations and geometries. But the resultant data is evaluated by a number of different cracking index protocols, including the Crack Indicatior (CI), the AASHTO interim Protocol, and the UK SCANNER method. This study demonstrates that ADA results can be effective at the network level when evaluated according to the CI and UK SCANNER methods. However, for the future implantation of automated pavement distress surveys, a simpler cracking protocol must be considered for development, one that can be utilized by a wide range of state pavement management engineers.

**Digital Highway Data Vehicle (DHDV) with LRIS (TRB 09-2014 pg. 15)**

**Performance-based uniformity coefficient of chip seal aggregate** by Ju Sang Lee and,Y. Richard Kim

A new chip seal performance index for aggregate gradation, developed by Lee and Kim, provides a new tool for the evaluation of aggregate. The performance indicator called the performance-based uniformity coefficient (PUC) is derived from the concepts of McLeod's failure criteria for chip seals and the coefficient used for soil, sand, and aggregate. According to McLeod, aggregate particles that are less than 50% embedded in the emulsion residue are likely to be dislodged. This study incorporates these failure criteria into the uniformity coefficient (UC), which is a measure of how uniformly particle sizes are distributed, to develop the performance-based uniformity coefficient. This new gradation-based performance indicator could be used as an aggregate selection tool and could clarify engineering communications within the chip seal industry.

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**Quieter HMA pavements in Washington State** by Pierce, Munden, Mahoney, Muench, Waters and Uhlmeyer

**Studded Tire Damage (wear) to HMA in Washington State (TRB 09-2205 pg. 4)**

Pierce, et. al. discuss the implications of using open-graded friction courses to reduce road noise. Although open-graded friction courses (OGFC) have been shown to reduce tire-related pavement noise, the surface life of these pavements is relatively short. Compared to the 16 year average surface life of dense-graded HMA pavements, OGFC pavements measured by the Washington State Department of Transportation for this study have surface lives ranging from 4 to 10 years. This study defines the primary cause of such early deterioration as the surface wear caused by studded tires. In addition, this pavement wear ends up reducing the initial noise benefits of OGFC pavements significantly. OGFC pavements, although they initially provide noise reduction benefits, are more expensive and less durable than standard dense-grade mixes. Furthermore, as OGFC pavements degrade, due to the wear caused by studded tires, they lose the ability to reduce road noise that made them an appealing alternative in the first place. This report concludes by defining OGFC pavements as, at this point, an unaffordable luxury.

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**Effect of crack sealant material and reservoir geometry on surface roughness of bituminous overlays** by W. James Wilde and Eddie N. Johnson

Wilde and Johnson describe a field test in Jackson County, Minnesota designed to evaluate the effects of crack sealant material and crack reservoir geometry on the formation of bumps in the application of single-lift overlays. The effects of crack sealant material type, the shape of routed cracks, and the pavement surface temperature were all considered as possible variables that could affect the formation of bumps. The results of this investigation demonstrate that hot-poured crumb rubber and hot-poured elastic sealants provided the best resistance to bump formation, also that cooler pavement surface temperatures resulted in less bump formation. Higher pavement temperatures at the time of overlay were shown to enhance the "slipping" or "sticking" of the sealant material.

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**Application of an Improved Crack Prediction Methodology in Florida's Highway Network** by Sahand Nasseri, Manjriker Gunaratne, Jidong Yang, and Abdenour Nazef

Statistical analysis can be used to investigate the two primary factors contributing to pavement deterioration: traffic loading and low structural integrity. The results of such an analysis by Nasseri et. al. demonstrate that the impacts of these two factors are statistically very different: cracks caused by low structural integrity deteriorate faster than cracks caused by traffic loading. This study suggests that crack deterioration is not dictated by traffic loading alone, and highway agencies must account for this fact in their decision making process. Bottom-up cracks, often caused by inferior sub-surface conditions at the time of overlay, intensify faster than top-bottom cracks, caused by traffic loading, causing these pavements to degrade faster. Therefore, pavement preservation agencies should not solely focus their decision-making on highly trafficked areas, as less trafficked areas with sub-surface stresses may be in more need of maintenance. By accounting for these two very different causes of cracking, relevant transition probability matrices (TPM) can present pavement engineers with a more realistic approach for predicting future pavement conditions.

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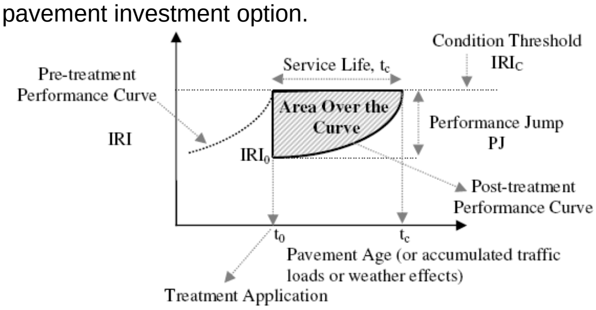
**Comparing the Methods for Evaluating Pavement Interventions – A Discussion and Case Study** by Muhammad Bilal Khurshid, Muhammad Irfan, and Samuel Labi

Khurshid, et. al. review evaluation criteria that have been used in past pavement preservation research, synthesizing evaluation techniques from both benefit and cost perspectives. Evaluative criteria, such as cost-effectiveness, treatment effectiveness, user-cost, and agency-cost, are comparatively analyzed using data from the Long Term Pavement Performance Program, a national pavement study. In this way, it is shown that evaluation results can vary widely depending on which criteria are prioritized. To achieve unbiased results, a matrix analysis, including various treatment/strategy alternatives, evaluation methods and performance criterion/measures, will be necessary to account for the various criteria. With this tool, pavement preservation decision makers can accurately select the best pavement investment option.




**Graphical Representation of AOC, TSL and PJ (TRB 09-2661 pg. 3)**

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**The Economics of Flexible Pavement Preservation** by Mary Stroup-Gardiner, and Shakir Shatnawi

Data made available by the Maintenance Technical Advisory Guide (MTAG), developed by the California Department of Transportation, is used to estimate the cost of pavement maintenance treatments. Particularly, the data was used to measure the impact of project size, restricted construction work times, existing road conditions, and delays in placing treatments on the final cost of pavement preservation. By developing economic comparisons of various pavement preservation treatments, this paper intends to give pavement management systems better information with which to make treatment decisions. For example, significant dollar-per-square-yard cost savings are achieved by organizing preservation work so that the contractor has several weeks of work in one geographical area. These economies of scale apply to AR chip seal, slurry seal, and crack sealing work, but not to PME chips seals or spray seals. Additionally, significant project-cost increases are incurred when projects are placed under tight construction time restrictions.

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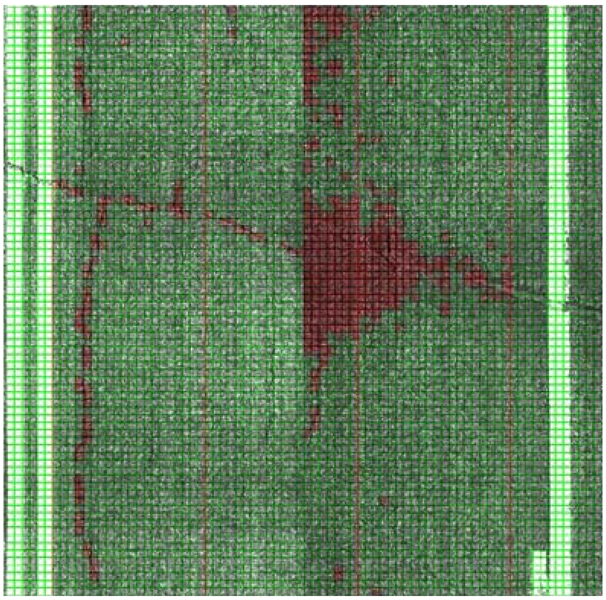
**Development of New Automated Crack Measurement Algorithm to Analyze Laser Images of Pavement Surface** by Jungyong "Joe" Kim and Hosin "David" Lee

Kim and Lee present a new automated crack measurement algorithm which allows for the accurate analysis of laser-collected road images. Traditionally, Laser Road Imaging Systems (LRIS) have proven to be difficult to analyze accurately due to the high contrast in the images, which generates a significant amount of background noise. This paper proposes the use of a new algorithm, based on the Retinex algorithm, for the accurate analysis of laser images gathered by LRIS. A regression analysis was performed to determine the optimal thresholding equation for the Retinex algorithm, then a set of 40 images were used to validate the new algorithm, comparing its results to those of existing thresholding methods. The new crack measurement algorithm demonstrates smaller precision error and greater accuracy than the existing global and local thresholding methods. This will provide an important tool to pavement preservation agencies collect road distress data through the use of laser-based Automated Image Collection Systems.



**Global Regression Thresholding Method (TRB 09-3672 pg. 6)**

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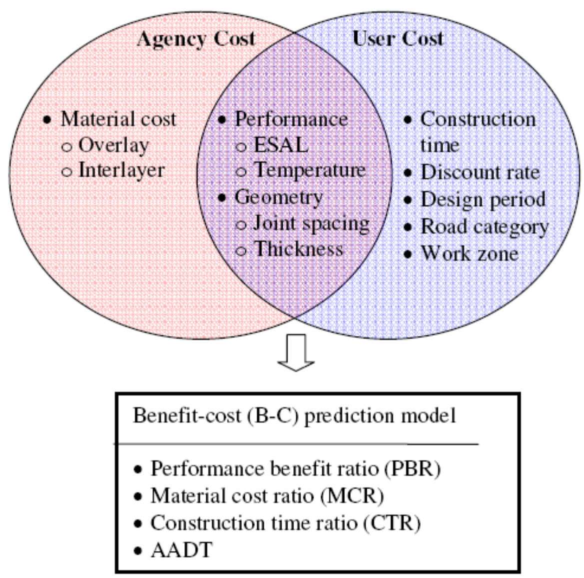
**Development of a Benefit-Cost Prediction Model for Hot-Mix Asphalt Overlays in Illinois to Evaluate the Cost Effectiveness of Interlayer Systems on Controlling Reflective Cracking** by J. Baek, I.L. Al-Qadi, and W.G. Buttlar

Baek, et. al., develop a benefit-cost ratio prediction model to assist in the selection of an interlayer system for hot-mix asphalt overlays. Performance of interlayer systems is dependent on traffic and environmental conditions, and material costs and construction requirements differ for each interlayer system. This variety of factors can make it difficult to determine the most efficient interlayer system for a specific location. By conducting a life-cycle cost analysis (LCCA) of three different interlayer systems in Illinois, this study computed a benefit-cost ratio for each system, incorporating the criteria of performance benefit, material cost, and construction time. These benefit-cost ratios were validated by crack survey results, and in comparative analysis, it is demonstrated that an interlayer stress-absorbing composite is most efficient in cold regions, whereas a sand-mix interlayer system is most efficient in warm regions.




**Main Variables of a B-C Prediction Model (TRB 09-3777 pg. 2)**

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COCKRELL SCHOOL OF ENGINEERING

# TEXAS PAVEMENT PRESERVATION CENTER

TxDOT

# Newsletter

ISSUE 14 / SPRING 2009

**Spring 2009 / Issue 14**

**Inside This Issue:**

**2009 Slurry Systems Workshop**





## Our Mission

The mission of the TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

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INTERNATIONAL SLURRY SURFACING ASSOCIATION

**2009**
**SLURRY SYSTEMS WORKSHOP**

Now including Chip Seal & Crack Treatment

**HANDS ON PROGRAM FOR ENGINEERS, INSPECTORS, AND INDUSTRY PERSONNEL**

## Past and Upcoming Events

### ISSA 2009 Slurry Systems Workshop

The TPPC was represented by Cindy Estakhri and Dr. Yetkin Yildirim at the International Slurry Surfacing Association (ISSA) 2009 Workshop held in Las Vegas, Nevada in January. This intense training workshop attracts over 275 attendees per year and is taught by industry experts. At this meeting, the TPPC acquired valuable information regarding the application and quality control of slurry seals, microsurfacing, and other maintenance treatments which can be used to shape future training courses. Included in this newsletter are brief summaries of some of the presentations given at the ISSA workshop.

### TPPC Seal Coat Training Courses

As part of our continuing mission to advance the field of pavement preservation, the Texas Pavement Preservation Center offered training courses on seal coats. The courses served two main groups: engineers and inspectors. The course designed for inspectors, entitled "Seal Coat Inspection and Applications," focused on proper inspection methods and the equipment used during chip seal construction. The other, "Seal Coat Planning and Design," instructed engineers on planning, designing, and constructing chip seals. The purpose of both courses was to increase the awareness and understanding of pavement preservation by providing instruction on a common preservative maintenance treatment.

### Slurry and Microsurfacing Overview

A slurry seal is a designed mixture of emulsified asphalt, mineral aggregate, mineral filler, water and other additives that are mixed to be uniformly spread over a properly prepared surface. Microsurfacing is similar to a slurry seal, except that in microsurfacing, the asphalt emulsion is polymer modified and break retarder is commonly used to control the mixing and working time of the material. The modification of residual asphalt with a polymer reduces the temperature susceptibility of the treatment. Microsurfacing mix can be placed in thicker lifts than slurry seal, and these thicker lifts can help maintaining the macrotexture and enhance the durability of the mix.

A slurry seal can be used to seal minor surface cracks, slow surface raveling, and improve surface friction. This treatment is usually applied to low-volume roads, such as city and county streets. Depending on the type of emulsion in the slurry mix, a curing period of two hours or more maybe be required before traffic can be readmitted on the roadway.

Slurry seals can be highly sensitive to local conditions and require an experienced crew to place properly. The crew must consider upper and lower air and pavement temperature limits, and adjust the mix accordingly.

Slurry seals are not effective treatments for badly cracked pavements. For slurry treatments to be successful, the pavement must be stable with no excessive rutting or shoving.

Microsurfacing is essentially a variation of slurry seal technology that employs polymer modified emulsion and crushed aggregates. Microsurfacing can be used for texturing, sealing, and rut filling on asphalt pavements. On cement pavements, it is used mostly for texturing.

Microsurfacing can be used to fill ruts if the underlying surface is stable, but for successful application, the existing pavement must be in a structurally stable condition. Microsurfacing does not increase the structural capacity of the pavement, although it does preserve the structural capacity by reducing moisture infiltration.

Microsurfacing requires that the pavement surface be prepared prior to treatment. Potholes should be repaired and cracks should be sealed before the application of a microsurfacing treatment. But when applied to properly prepared pavements, microsurfacing can resist wheel rutting and provide a skid resistant surface for up to 7 years.

However, microsurfacing and slurry seals each require special application equipment and a highly trained contractor for successful implementation.

### *2009 Slurry Systems Workshop*

**"Introduction to Slurry and Microsurfacing" by Mark McCollough**

Slurry seals and microsurfacing can be both preventative and corrective. As a preventative maintenance treatment, slurry seals and microsurfacing can be used to protect existing pavements from the effects of aging and weathering, delaying the formation of surface distresses and maximizing the existing pavement's surface life.


*Residential streets*

As a corrective maintenance treatment, slurry seals and microsurfacing can be applied to rehabilitate older pavements that already exhibit surface distresses. Slurry seals and microsurfacing can be used to restore raveling, rutted, or cracked pavements to serviceable condition.

Slurry seal surfacing and microsurfacing both act to seal the pavement surface and prevent further weathering of the underlying pavement. They also can help restore surface texture, fill cracks and voids, and provide the pavement with a new wearing surface.

Before application of slurry and microsurfacing, the pavement surface needs to be prepared by crack sealing, patching, protecting utility access points, blowing, and sweeping.

There are three gradations of aggregate for slurry sealing (Type I, II, III) and two for microsurfacing (Types II and III). Type I aggregate for slurry seals is generally used for the purpose of crack filling and fine sealing. The application rate is 8 – 12 lbs/yd2 based on weight of dry aggregate and Type I contains 10 – 16% residual asphalt. Type I slurry seal is mostly applied in residential streets, parking lots and airports.

Type II is the most widely used slurry seal gradation. Type II slurry seal is used to protect the underlying pavement from oxidation and water damage, correct severe raveling, and improve surface friction. It is used primarily for moderate traffic density pavements. Type II has an application rate of 10 – 20 lbs/yd2 and a residual asphalt content of 5.5 – 13.5 %.

Type III slurry seal is used to attain heavy application rates and high surface friction values on heavy traffic density roadways. Type III slurry seal can be used for pavement resurfacing. Type III has an application rate of 13 – 30 lbs/yd2 and a residual asphalt content of 5.5 – 12 %.

While slurry seals and microsurfacing both perform similar preventative functions, there are a few differences between them to be noted as well. In terms of their material capabilities, slurry seal is designed for one stone thickness while microsurfacing allows for stone stacking. Microsurfacing sets quicker than slurry seals, allowing for the least traffic disruption. Microsurfacing has more stringent performance criteria than the slurry seal, which requires a different mix design.

Slurry seals correct distresses such as raveling and light cracking, while microsurfacing corrects leveling course, light flushing, and rutting. Finally, the application equipment requirements are different for each treatment. Conventional slurry equipment can only apply slurry, while microsurfacing equipment can apply both slurry seal and microsurfacing.

Success in slurry seal and microsurfacing applications depends on site selection, equipment calibration, material consistency, contractor performance, project inspection and information.

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**"Slurry Seal and Microsurfacing Basics" by Barry Dun**

*Microsurfacing*

Slurry or microsurfacing can prevent surface distress while a pavement is still in good condition. These treatments protect pavement from the effects of aging, but only if they are applied before distresses become apparent. As preventative maintenance treatments, slurry and microsurfacing must be applied to a structurally sound system in order to provide substantial cost benefits.

By changing the binder in the mix, specific pavement conditions can be addressed. If its primarily function is sealing, the slurry mix should be rich in binder, whereas if the primary function of the treatment is to improve skid resistance, some asphalt should be removed from the mix, to make it a little drier.

To reduce reflective cracking, a chip seal may do a better job than slurry seal or microsurfacing. But slurry seals and microsurfacing have a unique ability to deposit the surface seal according to the surface demand of the pavement. Slurries do a better job than microsurfacing because they are richer in asphalt. Microsurfacing treatments tend to be fairly brittle, though not as brittle as a hot mix pavement.

When designing a mix, it is essential to know what kind of condition the mix will be placed on top of. Just because the emulsion and the aggregate both meet their respective specifications does not mean that they will be compatible with each other or with the existing pavement. A detailed understanding of the interactions between the different materials involved in the microsurfacing mix is required for a successful treatment application.

Crews should communicate with emulsion manufacturers regularly, for frequently proper slurry or microsurfacing emulsion formulations are determined by the weather conditions. When it is hot, more emulsifier is needed to allow sufficient working time. Inversely, at the end of the season when the weather is cool, the manufacturer can remove some emulsifier from the mix.

Too much water in the slurry or microsurfacing mix causes segregation. The slurry should be a creamy homogeneous mixture rolling over in the box rather than something that looks too wet and is splashing and segregating.

The individual components should be prequalified to ensure that the emulsion, the aggregate, the mineral filler, and the additives all meet specifications, then they can be combined according to the specific needs of the project. When the components have been combined into a good system, samples of the system should be subject to physical testing, which is part of the mix design process.

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**"Slurry and microsurfacing mix design" by Tony Ng**

Material selection, mix design, and testing procedures are different for slurry seals and microsurfacing. But in both cases, the function of mix design is to ensure that the finished product utilizes suitable materials in the correct proportions in order to meet the required standards.

The mix design methods for slurry and microsurfacing are outlined in the ISSA Technical Manual. While states and other U.S. authorities may have different requirements with regard to mix design test procedure, they usually use the same test procedures as ISSA guidelines. Different countries use different or modified ISSA test procedures.

*Cohesion Test Results*

According to ISSA A-105 and A-143, a "slurry seal is a designed mixture of emulsified asphalt, mineral aggregate, mineral filler, water, and specified additives that is proportioned, mixed and uniformly spread over a properly prepared surface." Microsurfacing on the other hand is a "designed mixture of polymer modified emulsified asphalt, mineral aggregates, mineral filler, water, and other additives," that is similarly prepared and applied to the pavement surface.

Some of the major differences between slurry seal and microsurfacing are the differences in material, durability, and application time. Material specifications are more stringent for microsurfacing than for slurry seals. Also, microsurfacing can be opened to traffic less than an hour after application, while slurry seal requires a longer curing time. Finally, microsurfacing must meet stricter durability standards than slurry seals.

The size and shape of the aggregate used will greatly affect the texture of the cured seal, so it is important to specify aggregate type in the mix design. In thicker lifts, the crushed aggregate provides the interlock needed for stability. Aggregate in thin surfacing must have excellent durability due to its increased exposure to the elements

Aggregate gradation also plays an important role in mix design since the proportion of fines and filler in the aggregate will greatly affect the mix time, workability, and the final consistency of the slurry. The proportion of the top size aggregate in the mix will also affect the final texture of the seal, and oversized aggregate will leave drag marks in the seal surface.

Mix design can be evaluated prior to application by the cohesion test, wet track abrasion test, loaded wheel test, and the Schulze-Breuer and Ruck (SBR) test. The cohesion test utilizes a power steering simulator that measures the torque required to tear a specimen. Different mixtures will develop adequate cohesion at different times, so the cohesion test can also be used to determine how quickly after curing a treatment can be opened to traffic. The SBR test is used to measure the compatibility of asphalt with the finest aggregate components. If the mix components are incompatible, long term moisture damage could destroy the finished pavement. The wet track abrasion test and loaded wheel test are used to determine the minumum and maximum emulsion content required for optimum material performance characteristics.

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**"Spreader Box Principles" by Scott Bergkamp**

A spreader box is an instrument that receives and contains the slurry or microsurfacing mix from the slurry machine. This tool evenly distributes the material across the paving width of the box, meters the material onto the road surface, and applies the final texture to the road surface.

The spreader box can be calibrated to typical application rates for slurry seals and microsurfacing through the application of a test strip. First, the paving box width must be set and recorded. Then the downward pressure of the primary strike-off should be adjusted to produce a J-shape. With the slurry or microsurfacing machine counters zeroed, the mix should be laid over a flat measured distance.

After the test strip is finished, the application rate can be determined by dividing the weight of aggregate used by the area of pavement surface covered. Adjustments to the spreader box can be made to ensure premium application of the slurry seal or microsurfacing mix. The box width, strike-off pressure, type and length of rubber/urethane, and auger clearance can all be adjusted for a precise application of the mix material. Too much pressure on the strike-off can result in the removal of larger aggregates from the system, and the length and stiffness of the rubber/urethane at the end of the strike-off will greatly affect the final surface texture.


*Rut filling*

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**"Introduction to Rubberized Emulsion Aggregate Slurry" by Mike O'Leary**

Rubberized Emulsion Aggregate Slurry (REAS) describes a polymer modified asphalt emulsion mixed with ground tire rubber. The application of REAS can help prevent surface distress, correct surface texture, and minimize the oxidation of pavement.

REAS is a pavement preservation tool that not only improves the existing pavement, but creates a new use for waste tire rubber. REAS is easily applied in cold form, is long-lasting, and has an aesthetically pleasing finish. REAS is a pavement preservation tool where the new pavement surface is ready for traffic just hours after treatment.

*Slurry Truck*

The materials used in REAS include crushed graded aggregate, specialized asphalt emulsion, SBR latex polymer, graded ground tire rubber, break control additives and stabilizers. Additionally, each gallon of REAS contains over one half pound of recycled tire rubber. For every mile of street (24 ft wide) treated with REAS, over 265 scrap tires are recycled. Since 1996, this pavement preservation treatment has accounted for the recycling of over 15 million pounds of used tires.

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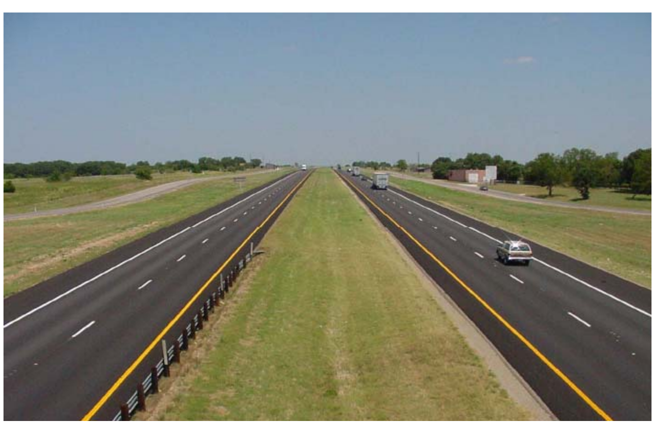
**"A Guide to Quality Construction" by Pierre Peltier**

The development of clear specifications can greatly improve the quality of a microsurfacing treatment. Agencies have certain expectations of pavement preservation treatments, like improved skid resistance, filled-in voids, and the ability to allow traffic on the road within one hour after treatment. Therefore, it is vital to the success of the project that the agency develop specifications thoroughly enough for the contractor to know what is expected.



*Microsurfaced pavement*

Mix design is a major variable that affects the quality of finished microsurfacing treatments. The types of materials used should be those specified and selected for the project, and materials testing should be performed on a regular basis. The existing pavement condition is also highly important; a properly prepared surface can increase the quality of a job significantly.

The field inspector and crew must be capable and knowledgeable in their respective areas. Good communication between everyone working on the project is crucial, in order for quality specifications to be met

Surface treatments fail due to material incompatibility, improper preparation, improper control of materials during application, poor traffic control, improper road selection, and poor timing. Quality control means avoiding these things and motivating workers to produce the best product possible.

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**Quality Assurance Guideline Summary for Microsurfacing**

A summary of the specifications prepared by TxDOT for inspectors, engineers, and crew members involved in the application of microsurfacing treatment is presented below.

According to TxDOT's guidelines, the selection and testing of the mixture components is the first step in designing a successful microsurfacing mixture. Materials acceptance requirements are the first specifications that must be considered in a microsurfacing treatment. Mixture design must also be approved before any microsurfacing work can commence.

During construction, inspectors may sample the material from the jobsite stockpile in a laboratory location. Mixture tests also may be conducted on samples taken from the microsurfacing application machine. These tests will ensure that the application machinery is performing at an acceptable level.

The Field Observation Checklist can be used to record information relating to the limitations that occurred during construction such as weather conditions, as well as the workmanship of the application crew. As a general guideline, microsurfacing should not be applied in rainy weather or if the temperature is below 50˚ F.

The surface must be cleared of all debris and slightly wet before the microsurfacing treatment can be spread. The surface should pre-wet so that the entire surface is damp but there is no free-flowing water. After the treatment, the finished surface should show no marks or streaks. Oversize aggregate particles can become lodged in the strike-off device during application, causing tear marks and furrows in the finished surface. If these surface marks occur too frequently, the treatment will not function properly.

More severe scratch and tear marks may be caused by improper strike-off equipment or an inappropriate surface thickness. It is not possible to place a microsurfacing layer that is thinner than 1.5 times the nominal maximum aggregate size.

If there are occasional problems with the microsurfacing application, workers can repair the aberrant sections with handwork, using a squeegee mop. However, areas of handwork should match, in texture and color, the surface produced by the spreader box.

Longitudinal and transverse joints should not appear disruptive. Joints with gaps or uncovered areas and joints with over a ½ inch buildup are not acceptable. In general, the total number of transverse joints should be minimized, unless the specific project plans dictate otherwise.

The edges of a microsurfacing application should also be uniform in appearance. When the edge of the pavement is not uniform, the machine operator must follow the edge as closely as possible, without allowing the spreader box to travel off the edge of the pavement.

**"Calibration of Slurry/Microsurfacing equipment" by Doug Hogue & Chad Davis**

In slurry surfacing, the mix design proportions are based on the combined weight of dry aggregate and mineral filler. To calibrate the machines to a given mix design, accurate information on the machine, aggregates, emulsified asphalt, water, and additives is necessary. Since the mix design is based on dry aggregate and dry mineral filler, corrections for moisture could be necessary.


*Dry Additive Calibration*

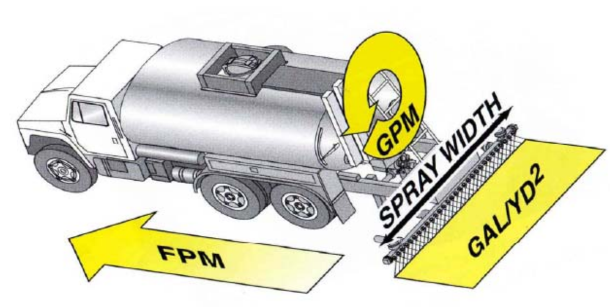
Calibration is necessary in order for the equipment to give accurate readings and measurements and to deliver a quality treatment application. The key component of calibration is the emulsion to aggregate ratio. Another important variable is water, which is typically adjusted by the operator during application.

The materials used for the calibration of slurry/microsurfacing equipment include water, mineral filler, aggregate, liquid additive, and polymer modified emulsion. Two types of pumps that are used for emulsion calibration are the Fixed Displacement Pump and the Variable Positive Displacement Pump.

The emulsion pumps can be calibrated by first determining the gross weight on the machine when loaded with the appropriate materials. Then, with the pump outlet secured to a second container, the desired number of counts can be run on the head pulley/emulsion counter. The weight of the emulsion in the second container is the weight of emulsion pumped. This weight, divided by the number of counts, equals the emulsion weight per count.

For aggregate calibration, the moisture content of the aggregate must be determined in the laboratory in accordance with ASTM C566-97. Then, three gate settings, or openings should be selected that will be used to perform the calibration. Next, the aggregate should be loaded into the hopper, and the loaded machine should be weighed. The calibration process is done three times for three different gates. The information from each run (trial) is recorded and weight per count is calculated.

**"Distributor Trucks – Calibrating today's computerized distributor trucks" by Brian Horner**




Calibrating a distributor truck requires adjusting the components in order to accurately achieve the shot rate preset in the computer. It is important to check the distributor calibration in order to make sure that the computer application rate reading matches the actual application rate. This will help avoid bleeding or flooding of the material, make sure there is enough material to retain the chip, and avoid increased cost of material due to over application.

Four key elements must be considered in the calibration of the distributor truck: the desired application rate in gallons per square yard, the forward ground speed in FPM, the asphalt pump output in gallons per minute, and the spray bar width in feet.

The distributor calibration can be checked by sticking the tank while the distributor is in level, or through the longitudinal rate test. Other distributor truck components to consider for calibration include the spray bar height, the nozzle angle, and the nozzle size. A spray bar set too high or too low relative to the pavement surface can cause streaking.

**"Seal Coats for Pavement Preservation" by Tom O'Leary**

A seal coat is generally a single, double, or triple application of asphalt material each covered with aggregate. Surface treatments are applied to prepared base courses or other surfaces. Seal coats are applied to existing pavements to extend the life of the pavements, and they have a life expectancy of approximately five years. The service life of a seal coat varies depending on situational conditions such as traffic volume and weather and the condition of the pavement they are placed on. Seal coats correct deficiencies such as cracks, raveling (or shelling), bleeding, aged or oxidized pavement, low skid resistance and also provide the appearance of a uniform surface.

Seal coats, however, will not strengthen existing pavement, increase load-bearing capacity, smooth out rough pavement, bridge major cracks wider than 1/8" (cracks wider than this size must be crack sealed in advance), or eliminate the need for maintenance or reconstruction. Typically, within the first three-quarters of the life cycle of a pavement, there is a 40% reduction in quality, but in the following 12% of the life cycle, the quality of the pavement plummets. Thus a seal coat should be applied early in this initial three-quarter period to be most cost effective.

Some factors affecting seal coat quality are: existing pavement surface condition, the experienced capability of workers applying the seal coat, equipment, materials, application technique, traffic, and weather. A raveled surface will require more binder; a slick surface will require a lighter binder. Bleeding pavements requires a lighter binder application rate.

*Seal Coat Application*

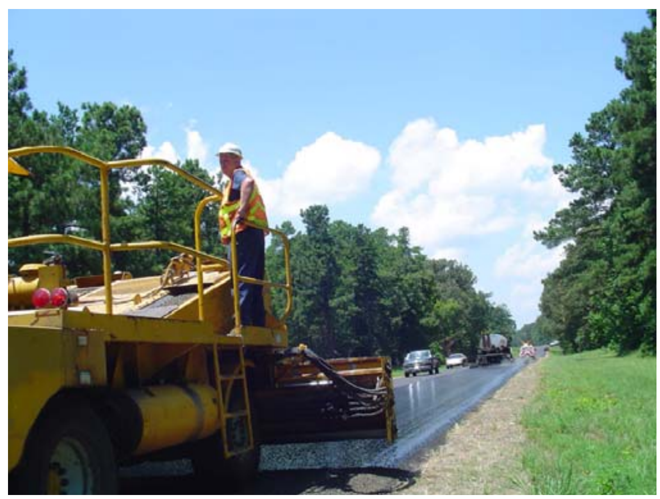
Seal coating is an art, not a science, and seal coat design is simply a starting point: be prepared to deviate from the design. It is necessary to have a good eye once you get out onto the road to see exactly what is going on. The contractor superintendent, engineer designer, inspectors, operators, suppliers and taxpayers all play a role.

Inspectors need to be adequately trained and need to have the freedom to make timely and informed field decisions. They need to develop partnering relationships with the contractor and suppliers and understand that plans are only a guide and that each road requires special considerations.

Suppliers are excellent resources for information on their respective products. Before applying a seal coat, an old roadway should be patched, crack sealed, and thoroughly cleaned. Likewise, unpaved surfaces need to be primed unless inverted prime techniques are being used. Keep in mind that hot or cold mix patches need adequate curing time. If this is not possible, then a fog seal on the new patches should be considered prior to the chip seal. Herbicide should be applied to surrounding vegetation, and gutter areas and curbs should be vacuumed, particularly in urban environments.

To prepare for seal coating, it is necessary to calibrate equipment, know proper design rates, understand factors affecting rate adjustments, determine rock lands, strap the distributor for accurate readings, and ensure that proper signing and traffic control are in place.

Calibrate the distributor's spray bar height, nozzle angle, spray bar pressure, and computer or asphalt meter. A double coverage spray nozzle pattern is most commonly used; a triple coverage spray nozzle pattern is not recommended because it is susceptible to wind, which will affect binder consistency. Computer-controlled aggregate spreaders need to be calibrated for proper rate distribution, and the gates and hitch need to operate properly. The area of the shot should be set to the quantity of the aggregate on hand rather than the size of the distributor so that binder gets covered in a timely fashion. Stockpiles should be placed in strategic locations for better production.



*Seal Coat Application*

It is extremely important that trained operators drive the aggregate spreader at a controlled ground speed to reduce skids and prevent rock from turning over. It cannot be overemphasized that the aggregate spreader should never move faster than the distributor. The spreader box should be directly behind the distributor (the quicker the aggregate gets applied, the better the bond will be). On high heat afternoons, however, the spreader box should back off slightly.

Trucks should be of adequate size and quantity. Measure and record the volume within each truck. Control the trucks' speed throughout the project. Stagger the dump trucks in and out of the wheel paths or station them down the roadway. Check tires periodically for proper inflation and cleanliness.

Rollers should be pneumatic only (three medium or four light pneumatic rollers are recommended), and tires should be clean and properly inflated. Rolling must take place immediately after the spreading of aggregate. The slower the roller moves the better, and rollers should always be moving because if it is sitting, it will squeeze aggregate down and push binder up. When a job is delayed for more than 10 minutes, rollers and trucks should be moved off of the fresh seal.

*Pneumatic Rollers*

For traffic control, flagmen, signs, and a pilot car are needed. The flagging stations should be constantly moved, and the pilot car should maintain slow speeds. Traffic control should also clean up messes; clean-up must be done immediately because on a hot day, a mess will get tracked through a whole job.

The proper aggregate for seal coating should be clean, single-sized, and cubical for optimum performance; avoid flat particle shapes and uncrushed gravel since these do not offer skid resistance. Do not use pre-coated aggregate with emulsion binder because it has a tendency to dramatically slow the break of the emulsion and will stay tender for a very long time. Pre-coated aggregates should only be used with hot AC binders.

The cost of single-sized aggregate deters their usage in most states, but a method to determine the number of “flatter” particles should be used when using graded aggregates. Aggregate with minimal fines should be used since fines will settle at the bottom if there are too many in the mix, preventing the proper embedment of larger aggregate into the binder and resulting in the loss of cover stone and bleeding. Natural and synthetic aggregate can be used. Aggregate selection depends on the type of roadway, volume of traffic, existing weather conditions, availability of aggregate, and cost.

Voids are the spaces between the aggregate particles; as aggregate particles are dropped into wet asphalt settling should occur in disoriented positions. After rolling and traffic, aggregate will be seated in their flattest position. Voids should account for 20-30% of the area before rolling and should account for roughly 20% of the area after rolling. For good performance, voids should not be filled completely with asphalt binder. On low volume roads, voids should generally be 40-50% full. On higher volume roads, voids should be only 30-40% full.

Hot AC is typically applied at 320-350°F. Hot AC loses 150-200°F in the first 30-45 sec. after application, so it is imperative to apply aggregate on AC while it is still very hot. The more fluid the binder is, the better it will adhere to the aggregate. Application of aggregate should be one rock thick, and if aggregate is applied correctly, there should be little or no remaining excess to sweep after a job.

To avoid excess joints, asphalt should be applied to the entire area, including intersections and widening, before aggregate is applied. Paper the joints at all starting and stopping points, and shoot on clean surfaces only. Use 1/2 nozzles or end nozzles on longitudinal joints. Nozzles should never be squared because doing so will actually produce a double shot; two nozzles are needed for a proper shot.


*Start and Stop on Paper*

Marginal surface temperature requires excellent construction techniques. Do not shoot too late in the day if working under questionable weather conditions; there needs to be plenty of time for proper curing before nightfall, since it is typically the wet or cold nighttime conditions that will ruin a seal coat.

Operators are often under pressure to get a job done and may be inclined to rush. Under these conditions, when tracking occurs, the first instinct is to raise the aggregate rate. This is the wrong thing to do. In reality, trimming the rock rate will stop the tracking. Aggregate rate is extremely important and affects more than just the look of the road. Too much aggregate will cause binder to push up.

In a high traffic situation, skid marks occur where trucks have to stop for traffic. An innovative way to solve this problem is to break up the application. Shoot three miles, and then skip a shot for the next 3,000 feet. This way, traffic always starts and stops on the old surface. At the end of the day, fill in the parts that were skipped. By doing this, skid marks can be avoided and patching will be unnecessary. In a day, one transport load of production may be lost, but no patching will be required.

THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COCKRELL SCHOOL OF ENGINEERING

# TEXAS PAVEMENT PRESERVATION CENTER

TxDOT Newsletter

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**Summer 2009 / Issue 15**

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## TPPC Board of Directors



## Our Mission

The mission of the TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

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## Past and Upcoming Events

### Regional TVAR Workshop

The TxDOT Regional Workshop on Transversely Varying Asphalt Rates (TVAR) was held in Austin on April 30. When applying seal coats, the asphalt rate can be varied across the width of the roadway in order to better address the needs of the existing pavement surface. The practice of TVAR can improve the performance of seal coats on pavements with flushed surfaces by adjusting the asphalt application rates to account for the difference between the wheel paths and the rest of the pavement. This workshop provided participants with detailed information regarding the use of TVAR, and concluded with a demonstration of the sand patch test – a valuable tool for the determination of proper asphalt rates. Videos of this workshop and additional instructional materials regarding TVAR will be available for use online at: http://www.utexas.edu/research/tppc/index.html.

### TPPC Seal Coat Training Courses

Seal Coat training courses will continue to be offered by the TPPC. The course designed for inspectors, entitled "Seal Coat Inspection and Applications," focused on proper inspection methods and the equipment used during chip seal construction. The other, "Seal Coat Planning and Design," instructed engineers on planning, designing, and constructing chip seals.

***TxDOT Regional TVAR Workshop***

**Figure 1. Sand Patch Test Demonstration**

## Defining TVAR

Transverse Variance of Asphalt Rates (TVAR) is the seal coat practice of varying the amount of seal coat asphalt across the width of the roadway in order to better address the needs of the existing pavement surface. TVAR can improve the performance of seal coats on pavements with flushed surfaces by adjusting the asphalt application rates to account for the difference between the wheel paths and the rest of the pavement. TVAR allows more asphalt to be put on the road without causing flushing in the wheel paths, resulting in a better seal overall. This practice can be used to improve the skid properties of the roadway by reducing wheel path flushing, while at the same time providing adequate asphalt coverage outside of the wheel paths to securely hold aggregate.

Optimal roadway performance requires that the wheel path need for asphalt rates be the engineer's primary concern. But it is a common misconception that TVAR, in order to eliminate the potential of seal coat flushing, reduces the amount of asphalt placed on a roadway. In fact, TVAR increases the total amount of asphalt placed on the road. After designing an asphalt rate based on the needs of the wheel path, this rate is increased for the areas outside of the wheel path. So if previous practice has been to design an application rate for the whole roadway based only on the needs of the wheel paths, then TVAR will allow for more asphalt on the roadway than would have been possible with a single-rate application.

## Where to use TVAR

Asphalt rates should be transversely varied wherever asphalt demand varies across the width of the road. Compared to the current seal coat practice of averaging asphalt needs across the roadway, TVAR will reduce the reoccurrence of wheel path flushing, as well as improve aggregate retention outside of the wheel paths. By meeting the specific needs of different regions of the existing pavement surface, TVAR has the potential to increase the longevity of seal coat treatments.

TVAR may be placed on any pavement surface, but is most effective when severe flushing causes a large degree of texture difference between the wheel path and the rest of the pavement. Usually, these texture differences occur on roads with prior seal coats.
TVAR can be used with both hot asphalt cements and emulsions, and has demonstrated limited success with rubber asphalt. Additionally, aggregate type is not a factor, though many experienced practitioners of TVAR warn against using it with Grade 5 aggregate.


**Figure 2. From the TxDOT Guide for TVAR, 2009**

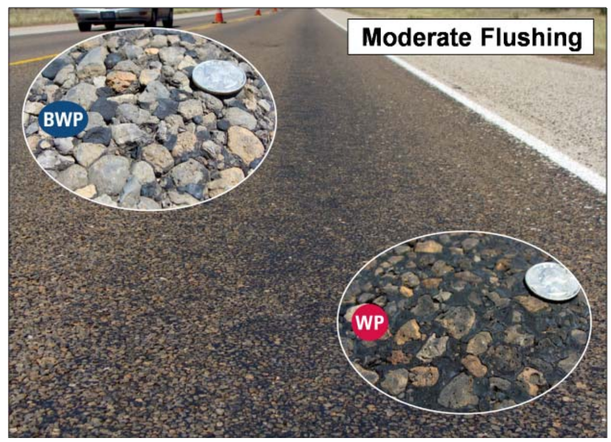


**Figure 3. From the TxDOT Guide for TVAR, 2009**

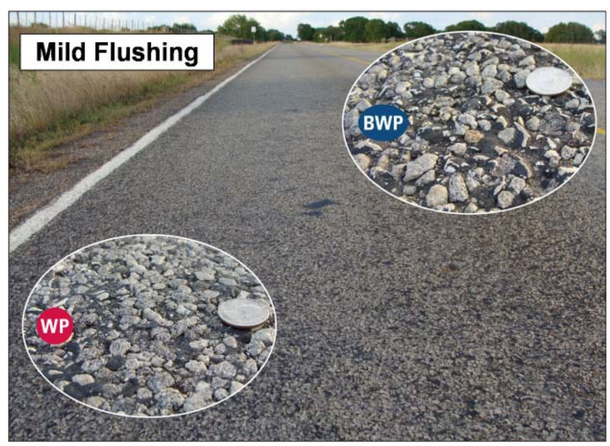


**Figure 4. From the TxDOT Guide for TVAR, 2009**

TVAR should not be used on new construction, but only with seal coat applications. Also, asphalt rates should not be varied on road surfaces that do not exhibit consistent traffic patterns, such as shoulders, parking lots, or continuous left-hand turn lanes. Finally, emulsions on rutted or super-elevated pavements should not be considered for TVAR since the uneven road surface might allow for the emulsion to flow back into the wheel paths, disrupting the designed rate and cancelling the potential benefit of TVAR.

### Selecting Shot Rates

The asphalt application rate must be designed to meet the needs of the wheel path first. TxDOT's *Seal Coat Surface and Treatment Manual* describes a method for selecting a rate which will adequately hold the aggregate without later allowing asphalt to flush to the surface. Once this wheel path rate has been chosen, the engineer should decide if the pavement in question is a good candidate for TVAR. The next decision is whether or not the asphalt rate outside of the wheel paths should be increased, and if so, how much variance there should be.


**Figure 5. Dual Spray Bar Distributor**

The amount of variation will often depend upon the type of distributor that is available for the seal coat project. When the contractor is using a single spray bar distributor, transverse variance can only be obtained through the use of different nozzle sizes across a single spray bar. This limits the potential range of rate variations, which in turn will affect the determination of shot rates. But by using a combination of standard nozzles sizes, contractors with a single spray bar can usually provide an asphalt rate increase outside of the wheel path in the range of 22-33%. So when using a single spray-bar distributor, the engineer must typically decide between this rate increase in the range of 22 to 33% or no rate increase at all.

On the other hand, distributors with dual spray bars can allow for more subtle rate variations. In this case, a broader and more optimal use of TVAR is possible. An asphalt rate increase of 10 to 15% outside of the wheel paths can address pavements with mild wheel path texture differences, and experienced inspectors can dial up specific percentage variations for different sections of the same roadway. However, if neither the inspector nor the contractor has much experience with TVAR, it is recommended that the possible variations be simplified to three choices: no increase, 10-15% increase outside of the wheel paths, and 22-33% increase outside of the wheel paths.

### Sand Patch Test

If visual determination is inconclusive, a simple pavement surface test can be performed in order to quantify pavement condition and assist in the TVAR decision. The sand patch test, described in Tex-436-A, should be used if there is any uncertainty regarding the appropriate TVAR difference.

**Figure 6. The Sand Patch Test**

In this test, a fixed amount of sand is poured into a conical pile on the surface of the roadway in the wheel path area. Then, with light, circular motions, the pile is spread into a circle until the sand is at the same level as the highest aggregates, as shown in Figure 7.

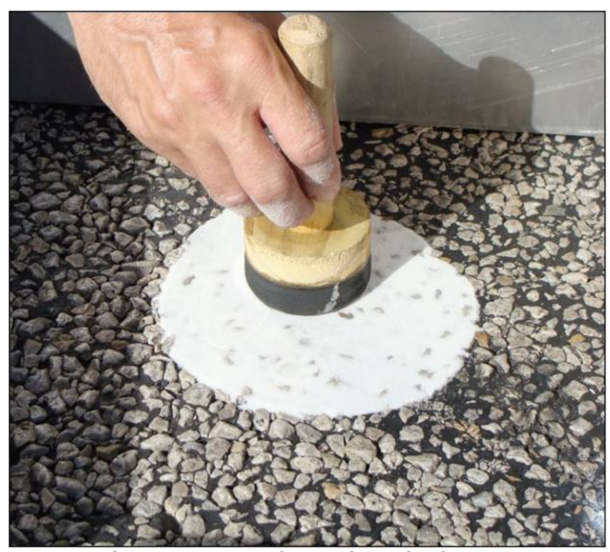

**Figure 7. A Sample Sand Patch Diameter**

The diameter of the resulting circle should be measured four times, and the average of these measurements will provide an indication of the surface texture. Next, the test should be performed with the same volume of sand on the pavement surface outside of the wheel path.

The difference in the resulting sand patch diameters will correspond to the difference in pavement textures, since a fixed amount of sand is used in each case. The more open the surface texture is, the smaller the sand patch diameter will be. On the other hand, heavily flushed pavements will yield a sand patch with a very large diameter, since there are fewer voids in the pavement texture.

**Figure 8. Measuring the Diameter of the Sand Patch**

The degree of difference between the sand patch in the wheel path and the sand patch outside of the wheel path should provide a helpful indication of the appropriate asphalt rate variation.

**Figure 9. High Pavement Texture Difference**

As a general guideline, if the difference in sand patch average diameters is less than 20 mm, the asphalt rate should not be increased outside of the wheel paths. If the difference is between 21 and 50 mm, the asphalt rate should be increased by 15% outside of the wheel paths (This 15% rate assumes that the contractor is using a dual spray bar distributor). Finally, if the difference in sand patch diameters between the wheel path and the rest of the pavement is greater than 50 mm, a 30% asphalt rate increase outside of the wheel path is appropriate.

## Distributor Inspection

The contractor is required to provide the selection of nozzles that will provide the designed asphalt rate variation, but the inspector must define the desired wheel path locations, effectively letting the contractor know where to place the various nozzles. Usually, nine nozzles on the spray bar will cover a 3-foot wheel path, but the exact nozzle configuration is the decision of the inspector, and must match the wheel path widths and locations of the actual roadway.

The following chart provides an example of different nozzle configurations based on recommendations by the Brownwood and Bryan districts.

| Lane Width, Feet | Number of Center Line to Wheel Path Nozzles | Number of Inside Wheel Path Nozzles | Number of Between Wheel Path Nozzles | Number of Outside Wheel Path Nozzles | Number of Wheel Path to Pavement Edge Nozzles |
|---|---|---|---|---|---|
| 9 | 1 | 9 | 6 | 9 | 2 |
| 10 | 2 | 9 | 6 | 9 | 4 |
| 11 | 4 | 9 | 7 | 9 | 4 |
| 12 | 5 | 9 | 8 | 9 | 5 |
| 12 (with edge line) | 6 | 9 | 8 | 9 | 4 |
| 13 | 7 | 9 | 8 | 9 | 6 |

**Figure 6. Suggested Nozzle Configurations**

To ensure the proper application of transversely varied asphalt rates, the contractor and the inspector must both understand how to communicate the desired rate variation to the distributor's computerized controls. If the contractor is using a distributor with dual spray bars, each controlled by separate computers, then the asphalt rate to be entered into each computer is the rate that is expected from that spray bar. One spray bar will apply the asphalt rate determined for the wheel paths, and the other will apply the rate determined for outside of the wheel paths.

But if the contractor is using a distributor with a single spray bar, the asphalt rate entered into the computer should be a weighted average of the two transversely varied rates. The correct entry of this information is critical for the success of any TVAR application. The average asphalt application rate in gal/sy (gallons per square yard) to be set on the distributors computer, when varying nozzle sizes are used on a single spray bar, can be determined with the following formula:

$[(L/100) \times (V/100) \times R] + R =$ Average Rate

Where: $L$ = % of larger nozzles = (number of larger nozzles/total number of nozzles) x 100; $V$ = % increase in asphalt rate selected for outside of the wheel paths; and $R$ = design rate of asphalt application for the wheel paths in gal/sy.

## Calibration

When preparing to use TVAR, first the contractor must perform his usual calibrations. These calibrations ensure that the distributor is able to apply asphalt at a near uniform rate. Then, the contractor must additionally demonstrate that the distributor is capable of providing transversely varied asphalt rates at the designed percentages. A single bar distributor must be able to provide a TVAR increase within the range of 22 to 33 percent. If the contractor is using a dual bar distributor, the inspector should request a demonstration of the distributor's ability to provide at least two variation rates, preferably 15% and at 30%. If the distributor is able to adequately meet these standards, then it should be able to provide any variation rate within the calibrated range.

### Adjusting Shot Rates

The condition of the resulting seal coat should be the basis for making adjustments to the TVAR percentage. Inspection of embedment depth both inside and outside of the wheel paths should be performed immediately after rolling, then again after the pavement has been subject to one or two days of traffic. 30% embedment is judged satisfactory immediately after rolling; ideally the aggregate embedment will increase to about 40% after several days of traffic.

### Specifications for TVAR

Standard Specification Item 316 already allows for transverse variation in asphalt rate, so no special provision is needed. It is only necessary to include a plan note further define the use of TVAR in the project, and to clarify the necessary additional distributor calibration procedures. A recommended plan note is included in the TxDOT *Guide for Transversely Varying Asphalt Rates*. The plan note makes it clear that the engineer, not the contractor, will be responsible for determining when to transversely vary asphalt rates. Also, it is suggested that the plan note require distributors to be able to provide at least one transversely varied asphalt rate in the range of 22 to 33%. This requirement allows contractors with both single spray bars and dual spray bars to bid on the seal coat project.

**Figure 7. Austin TVAR Workshop, Randy King, Yetkin Yildirim, Paul Krugler, Darlene Goehl**

### *TxDOT Legacy Knowledge Documents Regarding TVAR*

**Joe Higgins** works in the Abilene district, and has been familiar with TVAR practices for almost fifteen years. In the early days, he says he used variable nozzles on all roads in the district, shooting a wide range of variation: 20-40%. In his selection process, Higgins typically begins with a guess, basing the amount of variation on experience rather than calculation. "And then when I go back in twelve months and see that it is working fine, then maybe that was a good rate variation." Recently he has been requiring a variation in the range of 20-30%.

The need for TVAR is apparent, Higgins notices, on the roads that have been sealed two or three times over the years. When a road is either flushed in the wheel paths or has lost some rock between the wheel paths and outside the wheel paths, "To me, that is the biggest indication that something needs to be done differently," he says. The asphalt rate should be designed for the wheel path, and then an increased rate should be applied outside of the wheel path. "I tell my inspectors not to change their rock rate, but to hold it constant and alter the asphalt rate," Higgins explains, adding that asphalt rate should be adjusted based on traffic and pavement conditions only. According to Higgins, increasing the asphalt rate outside of the wheel path will help hold the rock and do a better job of sealing the pavement.

Higgins also stresses the importance of considering the time of application when evaluating asphalt rates. He recommends waiting 12 months to check a seal coat, then depending on how it looks, adjusting the rates to make recommendation for other roads in the district. But he cautions, "You can't totally judge the seal coat on whether or not you lose rock or get some flushing. The time of year that you shoot is critical." Higgins explains that if you shoot too late in the season, the pavement may not get hot enough for the rock to seat properly. In this case, the pavement may lose rock not because the asphalt rate was wrong, but because the seal coat was applied at the wrong time of year.

Higgins has never thought that embedment was an accurate measure of shot rates, and advises instead giving the pavement time to settle. "You have to wait and go through a winter and a summer to see if it's going to bleed or lose rocks," he says. "I trust what I have learned from experience about adjusting rates for traffic and road conditions instead of spending a lot of time looking at embedment."

**Darlene Goehl** has been transversely varying asphalt rates in the Bryan district for around ten years. She claims to use TVAR on about 50% of the seal coat locations in the district. "The director of construction and I ride all the roads in the district seal project a couple of weeks before the project starts," she says. At this time, Goehl sets up the asphalt rate table, and decides whether or not to use TVAR.

This is usually a visual determination, she explains. "We look to see if the wheel paths are visible. We also look to see if there is raveling outside of the wheel paths." In addition to this visual inspection, Goehl also considers traffic volume and road width when making her decision. At 1000 Annual Daily Traffic (ADT) or above, she usually opts for the variable rates. This ADT specification is a number that Goehl has come up with based on her experience observing the district roads. "I've noticed that somewhere around 1000 ADT we start noticing the wheel paths," she says.

**Figure 8. Embedment Slightly Higher than Desired**

The asphalt rate should be designed according to the wheel path. "It is all about embedment and embedment depth," she says. "The lower the ADT, the less embedment benefit you get from traffic, and the higher your asphalt rate needs to be in the wheel paths." But the low rate required by the wheel path may not provide enough asphalt to hold the aggregate outside of the wheel path. This is the main reason, according to Goehl, that variable rates should be used: to hold the aggregate outside the wheel path.

Goehl also advises that if TVAR is being applied with a single spray bar, the average shot rate is the rate that must be entered into the distributor's computer. "If you want 0.35 gal/sy asphalt outside the wheel paths and you are varying rates by 20%," she says, "Then you will have to set the computer at something like 0.39 gal/sy. This setting will give you about 0.42 gal/sy asphalt outside the wheel paths." It is important that the number entered into the computer is this average and not either of the two asphalt rates.

**John Baker** has been working with the Atlanta district's seal coat program since 1989. Initially, determining how and when to transversely vary the asphalt rate was hardly more than a guess, but Baker was determined to find a method that would help to quantify the decision. One thing he tried was the old sand patch test. "For instance, if I spread out 100 ml and the diameter is between 15 ½ and 19 ¾ inches, I would increase the asphalt rate 0.02 gal/sy to fill up those voids. Toward the other end of the range, if the diameter was between 7 ½ and 8 inches, I would increase the rate 0.10 gal/sy."

**Figure 9. Performing the Sand Patch Test**

The sand patch test allowed Baker to attach numbers to his observations of roadway conditions, and assists him in determining asphalt rates. The test doesn't need to be run on every pavement, he explains, only where there is uncertainty regarding the amount of variation to ask for.

The first thing that Baker looks at when determining whether or not to use TVAR is the condition of the wheel path. Most of the roads he observes have some degree of flushing or bleeding. First, he explains that the asphalt rate appropriate to the condition of the wheel path must be chosen, and then the rate can be increased for outside of the wheel path.

This rate selection, according to Baker, usually occurs about a week to ten days before the contractor begins work. "It's probably better to go out in the afternoon than first thing in the morning," he suggests. Once the sun as had a chance to heat up the pavement, Walker explains that "You get a better idea of how alive the asphalt gets in the wheel paths." This will help make a more accurate selection of the appropriate asphalt rate.

**Richard Walker** has been transversely varying asphalt rates for almost 40 years, and working in the Brownwood district for 28 of those years. He describes how the district used to make its own custom nozzles. "It was a tedious process involving a lot of trial and error," he says, because the variance of the nozzles changes depending on the viscosity of the asphalt and the pressure being used.

This is one of the reasons that Walker advises giving contractors a 10% variance range. "The reality is that the nozzles of just one size, when you buy them, can vary as much as 10%." Walker concludes from this margin that it will take at least a 20% asphalt rate variation to make a noticeable difference outside the wheel path, and recommends a 30% variation for most roads. Contractors with double spray bar distributors can be more precise, but Walker advises that "if you set up your specs for just the double bar distributor, you eliminate a lot of contractors and cause the cost to go up quite a bit."

Walker recalls that at times, when using emulsion, he increased the asphalt rate too much outside of the wheel paths. He warns that "If you go very far over 30%, the asphalt viscosity of emulsion allows some flow back." In this case, we were getting more asphalt in the wheel paths than we designed because the emulsion was flowing toward the wheel paths from the outside. Walker cautions that it is difficult to use TVAR methods with low viscosity emulsions.

He also warns that it is easy for the inspector to make mistakes regarding the placement of the various nozzles. "It's always good practice to check them at least every morning or when you move," he explains. "Sometimes at night, the operator might decide to clear out his nozzles and throw them all in a bucket. You never know what happens when you aren't there." Walker stresses the importance of verifying at every opportunity that the nozzles have been returned to their right places. Even during application, if one of the nozzles gets stopped up, the operator may remove it and accidently replace it with the wrong kind. "You always have to pay attention," he says.

In Walker's experience, varied asphalt rates should never be used to put less asphalt in the wheel paths. "Put exactly what the wheel paths require, then put more outside to hold the rock," he says. "You aren't shooting less to prevent flushing." Walker also reminds TVAR practitioners that it can take a year before you can tell if the rate you chose was right. The road has to go through a winter and a summer before the success of the TVAR seal coat can be determined.

**Randy King** works in the Brownwood district, which varies the asphalt rate on about 60-70% of their seal coats. King describes making asphalt rate decisions by driving the roads in the seal coat program one month before application, and observing the specific conditions. "Sometimes a road looks like a road we shot last year," he says, "And I'll go back and find the rate that I shot last year." His experience with TVAR has greatly facilitated the district's initial rate determination process.

King emphasizes the importance of experience in providing consistently positive results. "One thing that really helps to get good seals is to have the same guys out on the seal coat project year after year," he says. The experience gained through practice with TVAR allows for quick rate adjustments, and the ability to respond to the needs of the pavement surface. In his experience, the ability to make adjustments during application has been an essential component of Brownwood's TVAR success.

One important factor to consider when using emulsion, according to King, is the viscosity level. "If the wheel paths are depressed, emulsion will run down into them, giving you more asphalt than you designed for," he points out. For this reason, Brownwood added a viscosity check to their asphalt specification in order to ensure that TVAR could be used effectively with emulsions as well.

TVAR requires some extra calibration, as well. First, King explains, the contractor will do a calibration using the same sized nozzles on a straight bar to show that each nozzle is within 10% of the specified rate. Then, the contractor must put in the variable nozzles and perform a calibration to show that they will achieve the variation required by the plan note. King says that for this second calibration, they typically use the bucket test.

King encourages other districts that variable nozzles definitely work. "Look at your roadways, and use the variable nozzles on the roadways that really need them," he says. However, there are certain scenarios in which TVAR is not recommended. King cautions not to use TVAR if the district shoots grade 5 aggregate, if the existing seal is a microsurfacing treatment or a hot mix project, or if wheel paths are not visible due to irregular traffic patterns (left turn only lanes, in-town roadways, or parking lots).

**Paul Montgomery** works with TVAR in the Lufkin district. In his experience, transversely varying asphalt rates should result in more oil on the road, and a better seal overall. He also mentions the value of applying more asphalt to the shoulders of the roadway. "If you are just shooting the shoulders," Montgomery says, "You can aim for about 50% embedment, because you don't have to worry about tracking."

**Jimmy Parham** has been transversely varying asphalt rates for about eight to ten years in the Lufkin district. He diagnoses that 40 to 50% of the roads in the Lufkin district need TVAR, and the district's use of a contractor with a dual spray bar distributor allows Parham maximum flexibility when it comes to determining asphalt rates.

"I usually ride the roads beforehand, but the final decision is made the day we shoot the roads," Parham says. He sets the asphalt rates according to the visual appearance of the wheel paths, but also utilizes a small temperature gauge to check the roadway temperature and a small rock to check the potential embedment. "I'm trying to determine how much asphalt we already have out there," he explains. "The contactor will shoot oil that is 330˚ or 340˚ F, and that will liven up any asphalt that is already on the road." If too much asphalt is applied, considering what is already at the surface, the seal coat rock will be too deeply embedded once traffic gets on the road.

There are many other factors that influence Parham's rate adjustments. Hot oil will liven up the asphalt on the existing roadway more than emulsion, so asphalt type becomes an important factor in determining the appropriate asphalt application rates. Other factors to consider, Parham recommends, are the pavement type and the ADT numbers. "If you have a lot of heavy loads coming through," Parham suggests, "You want to try to shoot your wheel paths even lighter. Climbing lanes would be another example of a place to lower the shot rate a little more."

Parham checks his shot rates by looking at the embedment of the rock. After the rollers have gone through, 35% of the rock should be embedded. This number allows Parham to account for the future effects of weather and traffic. As an experienced practitioner of TVAR, Parham recommends that other districts who notice a lot of flushing give it a try. “You aren’t going to get every wheel path perfect,” he says, “But it will help you with the embedment of your rock.”

**Albert Quintanilla** works in the Laredo district, which has been using transversely variable asphalt rates off and on for the last ten years. Over the years, Quintanilla says that Laredo has probably varied asphalt rates at about 10% of its seal coat locations.

In this district, the asphalt rate is determined by consensus between the inspector and the contractor before the beginning of the seal coat project. Quintanilla aims for a variation that puts about 15% more asphalt outside of the wheel paths. “We allow the inspector to make limited adjustments to preset shot rates,” he adds. “I typically tell the inspector that he can increase the asphalt rate up to 0.05 gal/sy based on the existing pavement conditions, and up to 0.05 gal/sy based on traffic.” But the final decision is up to the engineer, and according to Quintanilla, the inspector is not allowed to increase the total asphalt rate by more than 0.06 gal/sy with the approval of the area engineer.

Quintanilla also emphasizes the importance of having good communication with the seal coat contractor. As long as they have enough lead time to change the nozzles without stopping the operation, Quintanilla notices that contractors typically don’t complain about TVAR. “If you let them know when the distributor gets to the location,” he suggests, the contractors “can change nozzles while they wait for the sweepers and rollers to show up.”

**Ernest Teague** works in the Paris district, and just started using transversely variable rates last year. When he first heard of the Brownwood district asking for 30% variation, he thought it was too much. He understands how it might be appropriate for very flushed wheel paths, but Teague wanted to use TVAR on all of his seal coats, which caused him to look for a way to get a smaller variation while still using a single spray bar.

He describes a unique method used in the Paris district to achieve a 10-15% rate variation with a single spray bar. Number 5 and Number 4 nozzles are alternated in the wheel path, allowing the fan spray patterns from the nozzles to overlap one another and give an average rate. “To get a uniform average,” Teague explains, “you need to set the spray bar height to get double overlap instead of triple.” The variation between this Number 4/Number 5 alternation and straight Number 5 nozzles is about 15%.