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Asphalt Technology News

In This Issue

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Renewed Agreement between NAPA and Auburn University Gives NCAT Solid Footing for Future

NCAT continues to move forward as a leader in the hot mix asphalt (HMA) industry through a permanent extension of the cooperative agreement between the National Asphalt Paving Association Research and Education Foundation (NAPA REF) and Auburn University. Originally established in 1986, NCAT has earned an international reputation for conducting practical research and providing training within the HMA industry.

"The College of Engineering is proud to be a partner in this effort," says Dr. Larry Benefield, dean of Auburn's Samuel Ginn College of Engineering. "Our faculty and staff have worked tirelessly to make NCAT the "go to" place for information on asphalt paving. NCAT's laboratories and test track are state-of-the-art, and have been actively leveraged to expand research and outreach in asphalt technology, as well as in additional transportation-related areas of research."

NAPA REF has committed a $10 million endowment to the Auburn University Foundation (AUF). NAPA REF has already provided $4.7 million and has committed an additional $5.3 million over the next five years. The gift will provide funding to help NCAT pursue its mission: providing research, education and information services to improve HMA pavements through technology advancement.

"This fund demonstrates the HMA industry's further commitment to ongoing research at NCAT," says Peter Wilson, Chairman of NAPA REF. "It's a long-term relationship that we want to continue."

The NCAT endowment was previously managed by NAPA through five-year agreements with Auburn. Transfer of the NAPA REF funding to the Auburn University Foundation was made in part to take advantage of the economies of scale allowed by consolidating fund management to Auburn's larger investment program.

"NAPA REF is very pleased with Auburn's management of the endowment and would like to thank Rob Wellbaum, Auburn's Associate Vice President for Development, for his hard work in making this possible," said Wilson.

"It's a win-win situation for both Auburn and NAPA," says Dan Gallagher, chairman of NCAT's board of directors. "There is a high level of trust and mutual respect that has allowed us to solidify this relationship. We are confident that NCAT, under the excellent leadership of Dr. Randy West, will continue to be an international leader in HMA research."

Revised Asphalt Layer Coefficient Will Result in Thinner Pavements

The Alabama Department of Transportation (ALDOT) is paving more highway miles with its resurfacing budget this year as a result of a study to recalibrate the asphalt layer coefficient. Using data from the NCAT test track, Dr. David Timm and graduate student Kendra Davis determined that asphalt pavements can be built approximately 18 percent thinner.

The AASHTO Guide for the Design of Pavement Structures – used by many state agencies, including ALDOT – utilizes layer coefficients for each material in order to determine the structural capacity of a pavement. For years, ALDOT has used a layer coefficient of 0.44 for hot mix asphalt (HMA) as recommended from the AASHO Road Test in Ottawa, Illinois, in the late 1950's. However, with modern improvements in paving materials and mix design methods, ALDOT decided it was time to revisit this standard.

The Study

The HMA layer coefficient was recalibrated using traffic and performance data from structural sections at the NCAT test track. Data from 14 structural sections built in the 2003 and 2006 test track cycles were used in the analysis. Four of the sections were in place for two cycles and accumulated approximately 20-million ESALs. The mixes were designed by Alabama, Florida, Missouri and Oklahoma DOTs and included dense-graded Superpave (with modified and unmodified binder), as well as stone matrix asphalt (SMA).

Using the 1993 AASHTO Design Guide flexible pavement design equation and an HMA layer coefficient of 0.44, the predicted amounts of traffic in ESALs were calculated to reach terminal levels of pavement serviceability. Serviceability was calculated from weekly International Roughness Index (IRI) measurements using NCAT's inertial profiler. To be conservative, the wheelpath with the most deterioration was used to quantify terminal serviceability. For sections with no major deterioration, an artificial terminal serviceability value was assigned.

The predicted ESALs for each section were then compared to the actual ESALs applied. To minimize the difference between the predicted and measured ESALs, a new layer coefficient was calculated for each section using least squares regression.

Results

Computed layer coefficients for each section are shown in Figure 1. The computed layer coefficients ranged from 0.41 to 0.68 with an average of 0.54 for all sections. Forensic investigations of the two sections with computed layer coefficients less than 0.44 revealed that the sections had poor bonds between asphalt layers, which led to premature cracking. No trends were observed relative to overall pavement cross-section, HMA mix type or binder grade.

Additional validation of the 0.54 value was obtained using the relationship between HMA layer coefficient and HMA modulus at 68°F, which is given graphically in the 1993 AASHTO Design Guide (see Figure 2). Using the average HMA modulus value (backcalculated using falling weight deflectometer data) for the structural sections of the 2003 NCAT Test Track, the relationship can be extrapolated to a layer coefficient of 0.543.

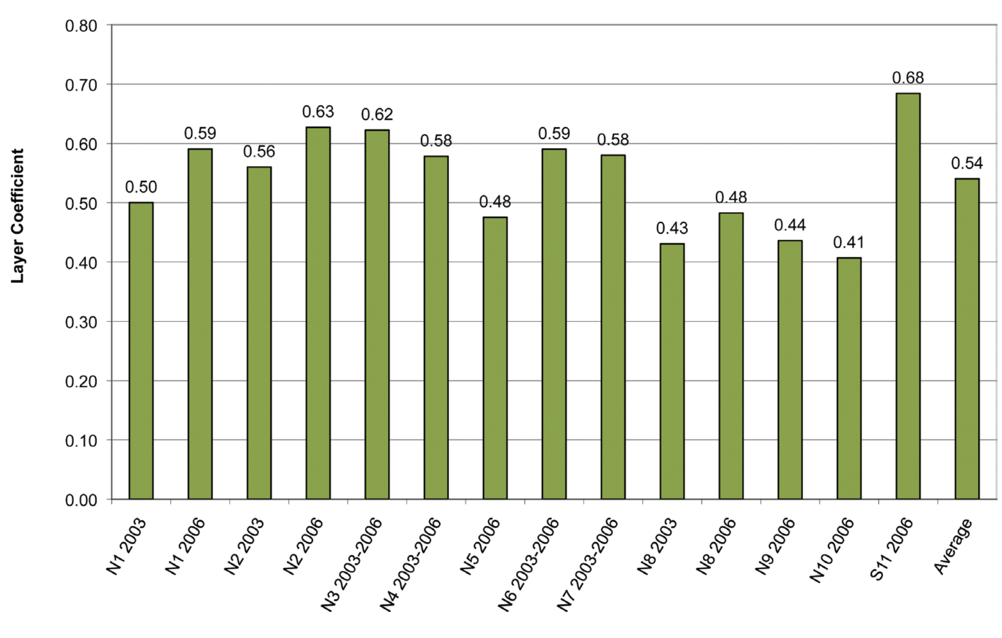


Figure 1. Computed layer coefficients for NCAT test track structural sections.

Implementation

For flexible pavement designs using the AASHTO Design Guide, an asphalt layer coefficient of 0.54 will result in approximately 18 percent thinner HMA cross-sections. This translates directly into cost savings per project and allows the agency to maintain more lane miles at a high level of service each year.

ALDOT has recently implemented the recalibrated asphalt layer coefficient for designing new construction, as well as resurfacing projects. ALDOT's minimum total asphalt thickness is 5 inches. While the new coefficient may be applicable to other states, Timm cautions that the environmental conditions and materials used in this study should be carefully reviewed first. The full report, Recalibration of the Asphalt Layer Coefficient, Report 09-03, is available at www.ncat.us and may be

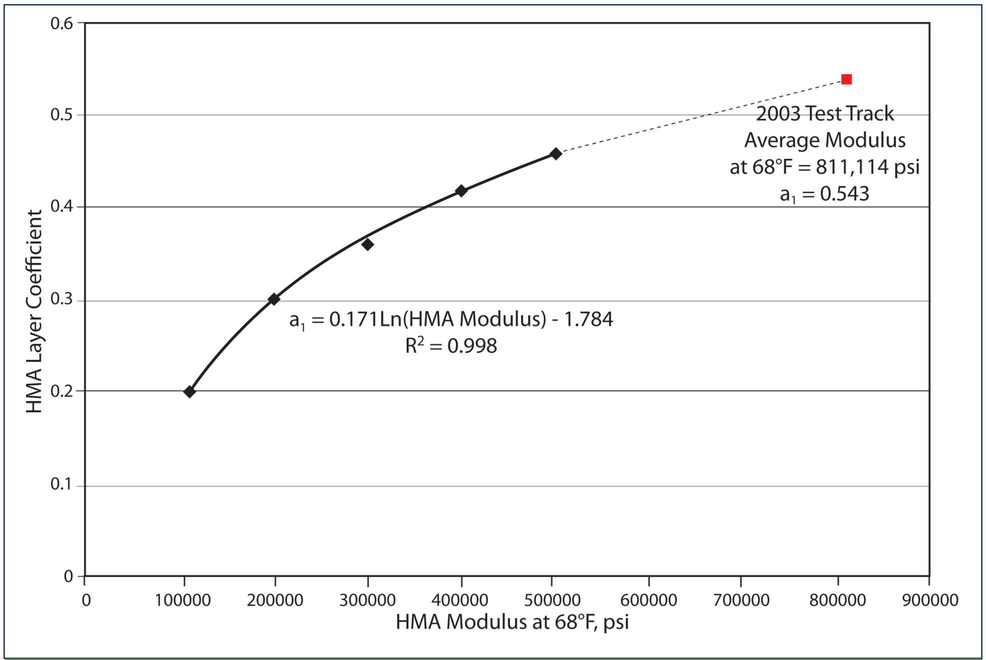


Figure 2. Relationship between HMA layer coefficient and HMA modulus at 68°F.

downloaded free of charge.

The recalibrated layer coefficient study has attracted a lot of attention around the country. Last fall, NCAT held two webinars on the subject that included approximately 120 participants from industry and state agencies across the U.S. and Canada. Davis and Timm have also given several presentations on the research at state and regional meetings.

Primer on Flow Number

To address the need for a simple performance test to accompany the Superpave mix design system, NCHRP 9-19 recommended the dynamic modulus (E*) and flow number (F_n) tests (also known as repeated load permanent deformation tests) as candidates for evaluating resistance to permanent deformation. E* has been used primarily for hot mix asphalt (HMA) materials characterization for pavement structural design using the Mechanistic-Empirical Pavement Design Guide (MEPDG), while F_n has been considered a potential performance test that might be used to indicate rutting resistance.

Asphalt Mixture Performance Tester (AMPT) from IPC Global.

Testing

The F_n test is performed on compacted asphalt specimens using the Asphalt Mixture Performance Tester (AMPT) or a servo-hydraulic testing machine capable of producing a controlled sinusoidal compressive loading. The AMPT equipment includes highly accurate systems for loading, measuring deformations and controlling test temperatures. An AMPT costs about $65,000 and can also be used to perform other tests, including dynamic modulus.

In the F_n test, a specimen is subjected to repeated axial compressive load cycles, each consisting of a pulse load applied for 0.1 sec, followed by a rest period of 0.9 sec. Permanent axial strain is measured as a function of the number of load cycles. Flow number is defined as the number of load cycles corresponding to the minimum permanent strain rate, as shown in Figure 1. A higher flow number indicates a more rut-resistant mix.

According to AASHTO TP 79-09, Standard Method of Test for Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT), the test is performed on three replicate specimens that are 150 mm high and 100 mm in diameter. Specimens may be obtained by coring gyratory-compacted samples and trimming each end of the sample. The test is usually conducted at the 50 percent reliability pavement temperature for a given location as determined using the LTPPBind software. A confining pressure of 10 psi is sometimes used for F_n testing, and research continues to evaluate whether unconfined or confined testing better simulates field conditions. The test takes about 3 hours per specimen, and the AMPT software automatically calculates the flow number.

Correlation with Field Performance

In order to establish appropriate acceptance criteria for the mix design process, correlations must be made between F_n and field rut depths. Previous studies, including mix samples from WesTrack and the FHWA's Accelerated Loading Facility (ALF), have shown reasonable correlations between F_n and field performance.

A recent study using data from the 2006 cycle of the NCAT Pavement Test Track also showed moderate correlations between F_n and field rut depths at 5- and 10-million equivalent single axle loads (ESALs). A reasonable correlation was also found between F_n and the rate of rutting (mm/million ESALs), which could be useful in the mix design process for determining F_n criteria at different design traffic levels.

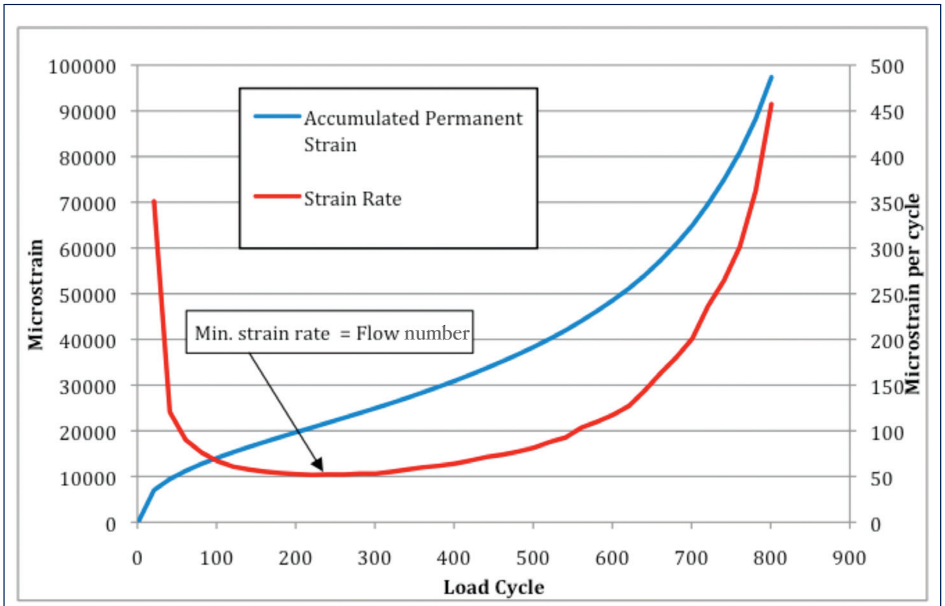


Figure 1. Flow number test data.

The flow number test shows promise as a potential performance test for evaluating mix designs, such as warm mix asphalt and high RAP content mixes. However, more research is needed to determine appropriate F_n acceptance criteria based on further correlations with field performance.

NCHRP 9-30A researchers recommend using results from the flow number test to determine coefficients in the rut depth transfer function included in the MEPDG software. The coefficients to the transfer function are then adjusted or shifted to field conditions. Default shift factors were developed using multiple test sections included in the FHWA-LTPP program and other full-scale test track test sections. In addition, the MEPDG software was modified so that specific HMA layer coefficients could be entered into the software. This modified software package is referred to as MEPDG – version 9-30A. This version allows users to predict rutting in the asphalt layer for a given set of loading and climatic conditions.

Committee Recommends Changes to AASHTO T 166

Under the direction of the Federal Highway Administration (FHWA) Asphalt Mix and Construction Expert Task Group, a subcommittee was charged to review current specific gravity measurement methods for aggregates and asphalt mixtures. Based on the review, which included current precision estimates, recent research studies and information provided by state agencies and equipment suppliers, the committee recommended the following revisions to AASHTO T 166 (bulk specific gravity of compacted specimens):

- Delete references to AASHTO T 275 (paraffin coating method) and replace with AASHTO T 331 (vacuum sealing method).
- Replace the current 2.0 percent water absorption limit for AASHTO T 166 specimens with a limit of 1.0 percent.
- Replace the incomplete precision statement contained in the current method (Section 13) with the precision estimates recommended by NCHRP 9-26. (See Table 1.)

Test and Type Index	Standard Deviation	Acceptable Range of Two Results
Single-Operator Precision	0.012	0.033
Multi-Laboratory Precision	0.016	0.044

Table 1. Acceptability of Bulk Specific Gravity Measurements

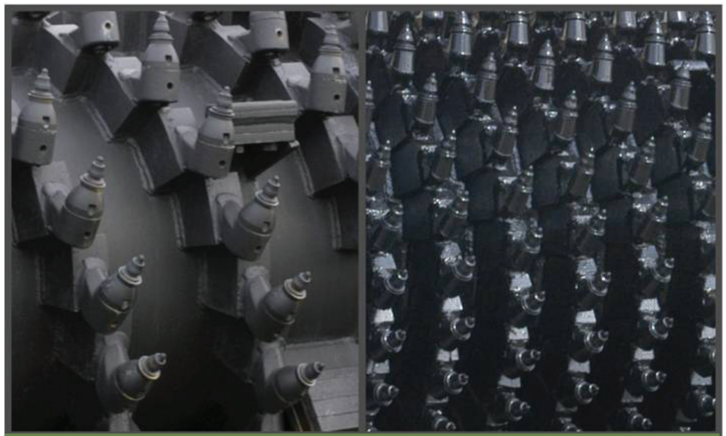
As a result of the proposed revisions, AASHTO T 166 will essentially be limited for use with fine-graded mixtures, while AASHTO T331 will be used for coarse-graded and stone matrix asphalt (SMA) mixtures. This will significantly affect mix design and quality assurance testing for coarse-graded and SMA mixtures, as summarized below:

- AASHTO T331 results in higher air voids and VMA for coarse-graded and SMA mixtures – approximately 0.5 and 0.9 percent, respectively, at normal mix design compactive efforts, based on available data. To provide performance equivalent to or better than currently used mix designs, agencies should consider increasing VMA criteria by 0.5 percent for both coarse-graded Superpave and SMA mixtures.
- AASHTO T331 also yields higher in-place air voids for coarse-graded and SMA mixtures – approximately 1.0 and 1.7 percent, respectively, based on available data. This change would require contractors to improve their compaction processes in order to meet existing in-place density requirements. Alternatively, agencies could adjust in-place density specifications consistent with the proposed measurement method so that density can be achieved with current compaction practices.

Micromilling Saves Georgia More Than $5 Million on Resurfacing Project

Cost-effective pavement preservation strategies are essential in today's tough economic climate. One means of extending pavement life, while stretching budget dollars is applying a thin hot mix asphalt (HMA) overlay. A relatively new technique, micromilling, can be used to effectively prepare an aging pavement for thin-lift surfacing by removing the distressed surface layer.

Micromilling utilizes a special drum with cutting bits spaced more closely together than a conventional milling drum. Bit or tooth spacing is 5/16 inch or less, depending on the manufacturer. A micromilling drum produces a fine-textured surface that is much smoother, with smaller ridges and valleys than a conventional milled surface. Also, the particle size of the recycled asphalt pavement (RAP) provided by micromilling is generally smaller and more uniform.



Traditional Drum Micro-Milling Drum

Case Study: Georgia I-75 Project

The Georgia Department of Transportation (GDOT) recently experimented with micromilling to remove a distressed open-graded friction course (OGFC) on I-75 south of Macon. This project had a dense graded 12.5 mm surface mix layer with an overlying OGFC that had been in service for more than 10 years. Although the OGFC had begun to deteriorate, the 12.5 mm mix was still in good condition. "We rut tested cores underwater in the APA (Asphalt Pavement Analyzer) at 64°C to determine that the underlying mix was in good shape," said Sheila Hines, State Bituminous Construction Engineer for GDOT.

Milling only the OGFC and replacing it with GDOT's currently used porous European mix (PEM) was the most cost-effective approach. However, this rehabilitation practice had rarely been done in Georgia due to several concerns. These included the potential for poor bonding between the PEM and the conventional milled surface and the potential for surface water to flow through the porous layer and become trapped in the valleys of the conventional milled surface, which usually has a ridge-to-valley depth (RVD) of 8 mm or greater. Because of these concerns, Georgia had typically placed a costly new layer of dense graded surface mix over the conventional milled surface prior to the PEM.

Solution: Micromilling

The fine-textured surface achieved by micromilling allowed GDOT to place a new PEM layer directly on the milled surface of the existing dense graded 12.5 mm surface mix, eliminating the need for an additional surface mix layer. GDOT estimated savings of $58,000 per lane mile or a total savings of approximately $5.4 million for the 15.6-mile I-75 project.

GDOT's texture specification for micromilling on the project included controlling the depth of the micromilled surface to an accuracy of 1.6 mm and maintaining RVD of 3.2 mm or less. Target smoothness was 825 mm/km, not to exceed 900 mm/km. NCAT assisted with research during the project by evaluating surface texture depths in the micromilled surface using the Circular Track Meter (CTM) and Ultra Light Inertial Profiler (ULIP). The Laser Road Profiler (LRP) was used to measure smoothness. Results indicated that the RVD requirements were achievable by keeping the milling speed approximately 20 ft/min or less.

GDOT has been pleased with the cost-effective strategy of using micromilling to remove distressed OGFC and replace it with PEM. The agency has also added software to the LRP to allow determination of RVD values while measuring smoothness. "We have awarded another [micromilling] project on I-95 that will be starting soon," said Hines.

After OGFC was removed using micromilling and replaced with PEM.

Progress on Goal to Increase RAP Contents

In 2008, the National Asphalt Pavement Association (NAPA) set a goal to double the national average recycled asphalt pavement (RAP) content from 12 percent to 24 percent by 2013. A recent survey conducted by Cecil Jones, a member of the Federal Highway Administration (FHWA) RAP Expert Task Group, shows that many states have already changed their specifications to permit more RAP in all layers of pavement.

"The evolution of generating, processing and handling RAP has progressed dramatically in the past 35 years," says David Newcomb, Vice President for Research and Technology at NAPA. "We have gotten to the point where we can do more recycling. We view it as a resource now, not a waste product."

Using more RAP makes sense economically and environmentally. Mixes containing higher RAP percentages have also been shown to provide excellent performance:

- A recent study of 18 Long Term Pavement Performance (LTPP) sections across the U.S. and Canada revealed that, in most cases, overlays containing approximately 30 percent RAP performed equal to or better than virgin pavements.
- In a 2007 Virginia Department of Transportation (VDOT) study, mixes containing up to 30 percent RAP compared favorably with standard VDOT mixes containing less than 20 percent RAP in laboratory tests for fatigue, rutting and moisture susceptibility.
- Test sections with moderate (20 percent) and high (45 percent) RAP surface mixes built on the NCAT Test Track in 2006 performed so well through 10-million equivalent single axle loads (ESALs) that the 45 percent RAP sections were left in place for at least one more cycle. New sections were added in 2009 to specifically evaluate the fatigue performance of high-RAP content mixes.

Recent studies have also shown that RAP can be successfully used in special mixes such as Stone Matrix Asphalt, thin-lift 4.75 mm mixes and open-graded mixes.

Across the U.S., agencies and researchers are working on pushing the envelope for better RAP utilization. Several studies are aimed specifically at answering the question of how much blending occurs between the old binder in the RAP and new virgin binder. In addition to the performance studies on the test track, NCAT is also working on modifications to the mix design procedure for high RAP contents and guidelines for managing RAP under NCHRP 9-46. This research should be completed by the end of December 2010.

Want more information? A new NAPA publication, "How to Increase RAP Usage and Ensure Pavement Performance," can be ordered online at **http://store.hotmix.org** or by calling 888.600.4474.

NCAT Plans Certification Process for Warm Mix Technologies

As warm mix asphalt (WMA) gains acceptance across the U.S., state agencies need verification of satisfactory performance in order to approve new WMA technologies for use on state-maintained roads. However, trial projects can be challenging and costly for WMA manufacturers to set up in many different states. To address this industry need, NCAT has begun a WMA certification program that will involve detailed evaluation of well-controlled test sections on the NCAT Test Track and a very comprehensive laboratory testing program. The field evaluation and lab testing plan are based on feedback from states across the U.S.

Certification cycles will occur annually and consist of three phases:

- **Mix Design** The Superpave mix design will incorporate all-virgin materials, including an aggregate that is historically susceptible to moisture damage. This will help determine if using a particular WMA technology increases the propensity for moisture damage. Each WMA technology will be incorporated into the mix design using recommendations from NCHRP 09-43: Mix Design Practices for Warm Mix Asphalt.
- **Field Evaluation** Each WMA section will be a 1.5-inch overlay placed in the curve of the NCAT Test Track and will be trafficked for one year, receiving approximately 5-million equivalent single axle loads (ESALs). Each section will be evaluated weekly for rutting, roughness, macrotexture and cracking. Additionally, cores will be taken quarterly to inspect for signs of moisture damage. A control hot mix asphalt (HMA) section of identical thickness will be constructed for each certification cycle, allowing NCAT to compare constructability and performance of each participating WMA technology with the control HMA section. The control HMA will have the same gradation as the WMA; the only difference in the mixes will be the WMA technology and mixing temperature.
- **Laboratory Evaluation** During construction, plant-produced WMA and HMA will be sampled for standard quality control testing, as well as further lab evaluation. Testing will include moisture sensitivity (tensile strength ratio, Hamburg wheel tracking test and the boil test), rutting (Asphalt Pavement Analyzer), permanent deformation (flow number), thermal cracking resistance, bond strength, stiffness (dynamic modulus), cracking potential (Texas Overlay Test), and recovered binder performance grade.

  If comparisons between a given WMA section and the HMA control section are favorable, the WMA product will be added to the certified list, which will be maintained on the NCAT website. Construction for the first WMA certification cycle is tentatively scheduled for May 2010.

NCAT invites your comments and questions, which may be submitted to Linda Kerr at kerrlin@eng.auburn.edu. Questions and responses are published in each issue of *Asphalt Technology News* with editing for consistency and space limitations.

Don Watson, NCAT

What criteria do agencies use to assess aggregate polishing characteristics for use in surface mixtures and/or chip seals? Other than the British Pendulum Test, what tests are used or recommended?

Don Watson, NCAT

Which states use VMA as an asphalt mixture acceptance criterion during daily production? If VMA is used for acceptance, how is G_{sb} determined? Is it based on test data at the time of production or historical data?

Chris Jones, Wiregrass Construction Company

Has anyone stored warm mix overnight in a silo? If so, at what temperature? Did it contain RAP?

Dale Rand, Texas Department of Transportation

The Pave-IR system, developed by researchers at the Texas Transportation Institute, provides a full-width thermal profile during paving, allowing contractors to detect thermal segregation as it occurs. Because it provides contractors with immediate feedback on their paving process, they are able to either prove that their process is effective or identify what they need to change to make it effective. If the contractor can demonstrate via the Pave-IR system that they can pave with essentially no thermal segregation, then we do not have to specify what equipment they should use, such as material transfer devices, remix pavers, etc. Since the Pave-IR bar collects and records data over the entire project, our inspectors do not have to be at the paver all the time, making it essentially a passive inspection device. Based on what I have seen so far, I am a 100 percent advocate of the Pave-IR system. It has the potential to promote quality paving far more than I have been able to in my 23 years in HMA construction.

Pave-IR System from Moba.

Asphalt Forum Responses

The following responses have been received to questions raised in the Fall 2009 Asphalt Forum.

1. Have any states had experiences with poor adhesion or placement of thermoplastic striping on surface courses containing polymer-modified binder? (Dave Powers, Ohio Department of Transportation)

Florida Department of Transportation, Greg Sholar

Florida has not had any problems with this.

Mississippi Department of Transportation, James Williams

We have not noticed any issues with thermoplastic and polymer-modified binder.

Missouri Department of Transportation, Joe Schroer

Due to poor adhesion to any surface during snow plowing, Missouri has discontinued the use of thermoplastic on roadways, except for high-traffic areas such as intersections.

Virginia Transportation Research Council, Bill Maupin

VDOT routinely uses PG 76-22 and limited amounts of PG 70-28 on high volume roadways. In most instances, inlaid B-VI tape is used for pavement markings. In instances where thermoplastic has been used, we are not aware of any problems.

2. a) Tennessee is slowly implementing the use of open-graded friction courses (OGFCs) to reduce wet weather accidents, but we have been receiving reports from district maintenance crews that these pavements are difficult to maintain during cold weather (de-icing, salting, plowing, etc.). Do any states have protocol for or maintenance issues with porous pavements?

b) Also, due to the cost of these mixes, we've typically only paved open-graded mixes just beyond the edge stripe but have experienced some safety issues with over-correcting drivers who veer over the edge of these surfaces. How far beyond the edge stripe do most states place porous mixes? (Mark Woods, Tennessee Department of Transportation)

Florida Department of Transportation, Greg Sholar

a) Florida has no special maintenance procedures for OGFC, but we do not have the cold weather issues that northern states have.
b) Florida also only paves beyond the edge stripe, but I am not aware of any safety issues related to that.

Mississippi Department of Transportation, James Williams

b) We place OGFC approximately two feet beyond the edge stripe. The mix extends out onto the paved shoulder and the rumble strip is placed on the paved shoulder section.

Missouri Department of Transportation, Joe Schroer

a) In areas where open-graded mixtures are used, more salt is required. It is generally rationalized that the reduction in accidents in these areas offsets the cost of the extra salt.
b) Missouri paves an additional 18- to 24-inches wider than the lane to accommodate striping and to move the edge away from traffic. Standard practice has become to place a seal coat on the shoulder to bring the remaining shoulder to the approximate elevation of the roadway.

Ohio Department of Transportation, Dave Powers

a) Ohio used OGFCs for years but has moved away from them due to the high cost of winter maintenance. OGFCs also presented issues with locating a supply of high-friction aggregate in some areas.
b) Ohio usually paved over the entire shoulder when OGFCs were used.

Oklahoma Department of Transportation, Kenneth Hobson

a) No.
b) We typically extend OGFC and PFC to the end of the shoulder. There may be a time interval before a full extension is completed.

Virginia Transportation Research Council, Bill Maupin

a) An NCHRP Synthesis, *Performance Survey on Open-Graded Friction Course Mixes*, dealt partially with this issue; it can be downloaded at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_284.pdf. VDOT used a lot of porous friction course (PFC) many years ago but discontinued them primarily because of related pavement durability issues. There was at least one instance when a storm caused a major safety problem on an Interstate highway but we do not have any winter maintenance data from that time period. VDOT has one recent test section with PFC near Washington, D.C. This section is pre-treated prior to winter weather events, is plowed and has abrasives applied when clearing the pavement. We have not experienced issues, but this is only our second winter monitoring this section.
b) We placed our recent PFC one to two feet beyond the edge line in order to minimize impacts related to over-correction by drivers. The thickness of the PFC is typically one inch or less; the maximum drop off allowed in the specifications is two inches. We are not aware of any safety concerns related to this section.

Florida

All gyratory compactors (state and contractor owned) are calibrated internally, effective January 1, 2010. The internal angle is set to 1.16 degrees.

Effective January 1, 2010, RAP material will require testing for AC content and gradation at a frequency of once per 1000 tons. Testing will also be required for G_{mm} and recovered viscosity at a frequency of once per 5000 tons of incoming RAP.

Effective January 1, 2010, warm mix asphalt (WMA) will be allowed for all mixture types at the discretion of the contractor. Minimum air temperature requirements are reduced 5°F when using warm mix.

Effective January 1, 2010, the use of non-vertical (oscillatory) means of vibratory compaction will be allowed in sensitive areas where other means of vibratory compaction are prohibited.

Effective July 1, 2010, FDOT will require a liquid anti-stripping agent in limestone open-graded friction course (OGFC) mixtures. Previously, anti-stripping additives were only required in granite OGFC mixtures, which required the use of hydrated lime.

Iowa

The Iowa DOT has developed a percent within limits (PWL) specification for asphalt concrete pavements. The specification will be used for all lettings after May 2010.

The Iowa DOT has also developed a specification for the use of recycled asphalt shingles (RAS), which can be found at http://www.iowadot.gov/specifications/dev_specs/DS-09038.pdf.

A warm mix asphalt developmental specification will also be available for the May 2010 letting.

Kentucky

In 2009, asphalt contractors in Kentucky placed nearly one million tons of warm mix asphalt (WMA), almost exclusively with the water-injection/asphalt-foaming process. This year, the Kentucky Transportation Cabinet (KYTC) is specifying numerous experimental projects involving WMA produced using a wax or chemical additive in order to gain experience with these technologies.

Also, due to a growing interest in the use of reclaimed asphalt shingles, KYTC is revising the applicable specifications to accommodate this material. These requirements will be based on the ratio of virgin asphalt binder to total asphalt binder and will apply to mixtures containing reclaimed asphalt pavement, reclaimed asphalt shingles or both.

Missouri

Missouri has ten pilot projects in which the smoothness measurements will be changing from profile index (PI) to international roughness index (IRI).

Oklahoma

Our 2009 Standard Specifications will be used on plans let starting June, 2010. The new specifications are available at http://www.okladot.state.ok.us/cnstrctengr.htm.

A permissive WMA specification is included with all projects let in 2010. Approved WMA technologies are listed on our website at http://www.okladot.state.ok.us/materials/htm-smap/11062p-ASA.htm.

A Hamburg rut test (OHD L-55) will most likely replace our APA rut test (OHD L-43) sometime in 2010. A maximum rut of ½ inch will be required for asphalt mixtures with binders PG 64-22, PG 70-28, and PG 76-28 at 10,000, 15,000, and 20,000 passes respectively. Test methods can be found at http://www.okladot.state.ok.us/materials/ohdllst.htm.

The specific gravity of binder is assumed to be 1.010 for asphalt mix designs. This makes binder source changes easier.

Tennessee

The Tennessee DOT is still evaluating a provisional specification in which roadway density acceptance is performed on core samples in lieu of nuclear gauge testing. This provision includes language for joint density acceptance cores to be cut directly over the joint

Texas

We have recently implemented a specification that does the following:

- Allows the use of substitute binders. For example, PG 64-22 could be used where PG 70-22 was specified, provided the mixture using the substitute binder has less than 10 mm rutting in the Hamburg Wheel test at the number of cycles required for the originally specified binder.
- Allows up to 5 percent recycled asphalt shingles (RAS), manufacturer waste or tear offs, in HMA mixes. Fractionated RAP is allowed at 20 percent for surface mixes, 30 percent for intermediate mixes and 40 percent for mixes placed more than eight inches from the final riding surface.
- Limits the ratio of recycled binder (binder from RAP or RAS) to total binder to 35 percent for surface mixes, 40 percent for intermediate mixes and 45 percent for mixes placed more than eight inches from the final riding surface.
- Allows the contractor the option to use WMA on all projects and allows TxDOT the option to require WMA by plan note.
- Provides significant incentives for contractors to use the Pave-IR (paver-mounted infrared bar) to detect thermal segregation. Incentives include allowing contractors to pave at lower temperatures, waiving existing requirements to perform a density profile every time the paver stops, and removing stipulations that contractors waive their right to earn a bonus if they fail a density profile or have severe thermal segregation (temperature differentials > 50°F). Contractors using the Pave-IR system must demonstrate that their paving process is essentially free of thermal segregation (temperature differentials >25°F) to take advantage of the incentives described above.

NCHRP Report 648: Mixing and Compaction Temperatures of Asphalt Binders in Hot Mix Asphalt

Randy West, Donald Watson, Pamela Turner and John Casola

The traditional procedure for determining laboratory mixing and compaction temperatures for hot mix asphalt (HMA) is based on viscosity measurements. However, this method often yields excessively high temperatures for modified binders, causing possible emissions problems and potential degradation of the binder's properties. Due to these concerns, many highway agencies have relied on binder suppliers to recommend mixing and compaction temperatures for each modified binder. The objective of the NCHRP 9-39 study was to identify or develop a simple, reliable and accurate laboratory procedure for determining mixing and compaction temperatures for both modified and unmodified binders.

The Study

The study was conducted by NCAT and John Casola of Malvern Instruments. Based on a literature review of several possible tests for determining mixing and compaction temperatures, the panel selected three candidate methods for a detailed laboratory evaluation:

- **High Shear Rate Viscosity** Developed by Yetkin Yildirim et al. in Texas, this method is based on evidence that most modified binders exhibit shear thinning behavior. It uses rotational viscometer measurements at two temperatures over a range of shear rates. The data is extrapolated to a higher shear rate of 500 1/s and plotted on a conventional log viscosity vs. log temperature chart to obtain temperatures corresponding to traditional viscosity criteria for mixing (0.17±0.02 Pa·s) and compaction (0.28±0.03 Pa·s).
- **Steady Shear Flow** This method was developed by Gerry Reinke and uses the dynamic shear rheometer (DSR) to measure viscosity in constant shear mode over a range of shear stresses and temperatures. The viscosity of most modified binders approaches steady state at higher shear stresses, around 500 Pa. Using a log viscosity vs. log temperature chart, viscosity results at 500 Pa are extrapolated to 180°C. Mixing temperature is then selected at the conventional viscosity criteria of 0.17±0.02 Pa·s, while compaction temperature is selected at Reinke's recommended viscosity of 0.35±0.03 Pa·s.
- **Phase Angle** John Casola developed this method, which is based on the observation that phase angle is a binder consistency property that accounts for the viscoelastic nature of asphalt binders. This method uses the DSR in oscillatory shear mode over a range of angular frequencies. The frequency sweep data is then used to construct a phase angle vs. frequency master curve at a reference temperature of 80°C. The frequency corresponding to a phase angle of 86° (the transition point between viscous and viscoelastic behavior) is then correlated to the temperatures at which binders provide good aggregate coating during mixing and lubrication during compaction.

Candidate methods were compared using modified and unmodified binders obtained from several binder suppliers across the U.S., including a range of crude sources, refining processes and modification systems. Tests were also conducted to assess emissions potential and binder degradation due to high-temperature exposure. In order to validate the mixing and compaction temperatures predicted by the candidate methods, lab mixture tests were used to assess the effect of temperature on aggregate coating during mixing, workability, compactability and low-temperature properties of asphalt mixtures.

Conclusions and Recommendations

The Steady Shear Flow and Phase Angle methods both provided lower mixing and compaction temperatures for modified binders than the traditional equiviscous method. These lower temperatures were not likely to cause emissions problems or binder degradation. However, the High Shear Rate Viscosity method resulted in higher temperatures that were very similar to those obtained using the traditional method, offering no improvement on the current procedure.

Both the Steady Shear Flow and Phase Angle methods provided reasonable mixing and compaction temperatures for the modified and unmodified binders used in the study. Results from both methods correlated well with the laboratory coating, workability and compactability test results. Both methods provided similar mixing and compaction temperatures for modified binders, while the Steady Shear Flow method generally yielded lower mixing and compaction temperatures for unmodified binders than the Phase Angle method.

Both the Steady Shear Flow and Phase Angle methods can be performed using standard DSR equipment, which is widely used in binder laboratories. However, DSR testing has some practical limitations, including the test temperatures at which binder properties are measured and the problems of particulate matter, such as ground rubber particles, that can interfere with the rheological response in the 1 mm gap of the instrument.

The Steady Shear Flow method and the Phase Angle method are both recommended for further evaluation in determining laboratory mixing and compaction temperatures. Future assessments should include validating the methods using a broader range of asphalt binders, refining the test procedures (including experimenting with alternate instrument geometries to avoid issues with temperatures and some filled binders) and establishing precision statements.

HVS Testing in California Shows Good Results for Three Warm-Mix Technologies

Preliminary results from the University of California Pavement Research Center (UCPRC) show that three warm mix asphalt (WMA) technologies performed comparably to hot mix asphalt (HMA) in accelerated pavement testing using the Heavy Vehicle Simulator (HVS). According to Dr. David Jones at UCPRC, "Caltrans sponsored the study to see if the use of WMA differed from HMA." Four test sections – Advera, Evotherm DAT, Sasobit, and an HMA control mix – were subjected to HVS testing to assess rutting potential and moisture sensitivity. Results indicated that the use of these three WMA technologies will not significantly influence rutting performance or increase the moisture susceptibility of the mix.

Construction

The test sections consisted of two 2.4-inch asphalt lifts and 12 inches of imported aggregate base over the existing subgrade. A Caltrans Hveem mix design (dense-graded, 19-mm maximum aggregate size) asphalt concrete was used for all four sections. No adjustments were made to the mix design for the warm mix technologies. Production temperatures for each of the WMA sections were approximately 60°F lower than the control mix. Later testing revealed that the Sasobit increased the binder grade, bumping it from PG 64-22 to PG 70-22. Due to a binder flow rate problem in the plant, the Sasobit section also had a lower binder content, which was expected to affect its performance.

Some tenderness was noted on the Evotherm and Sasobit sections, but adequate compaction was achieved on all sections. No other problems were experienced with construction of the WMA sections at lower temperatures, but improved working conditions were cited as a definite plus.

Test sections were confined between K-Rails to obtain uniform compaction during construction and prevent edge damage while maneuvering and positioning the HVS. This confinement also prevented water from entering the pavement structure.

Lab Testing

Specimens were cut from each test section as well as adjacent slabs compacted with lab equipment. Laboratory evaluations included shear testing (AASHTO T-320), fatigue testing (AASHTO T-321) and moisture sensitivity testing (AASHTO T-324 and Caltrans CT-371, which is similar to AASHTO T-283). Results of the laboratory evaluations are shown in Figures 1, 2 and 3. Shear and fatigue testing indicated that the three warm-mix technologies will not influence rutting or fatigue performance. Lab moisture sensitivity testing indicated that all four mixes were potentially susceptible to moisture damage, but there was no significant difference between the control mix and the mixes with additives.

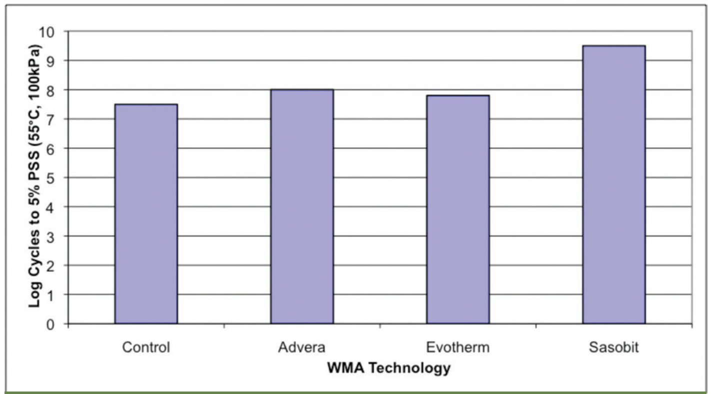


Figure 1. Summary of Laboratory Shear Performance

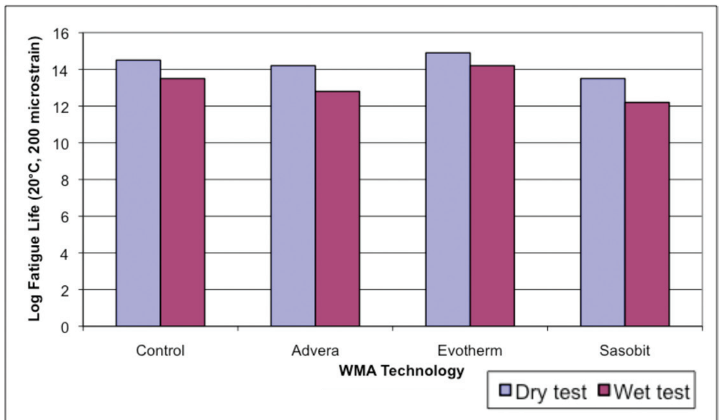


Figure 2. Summary of Laboratory Fatigue Performance

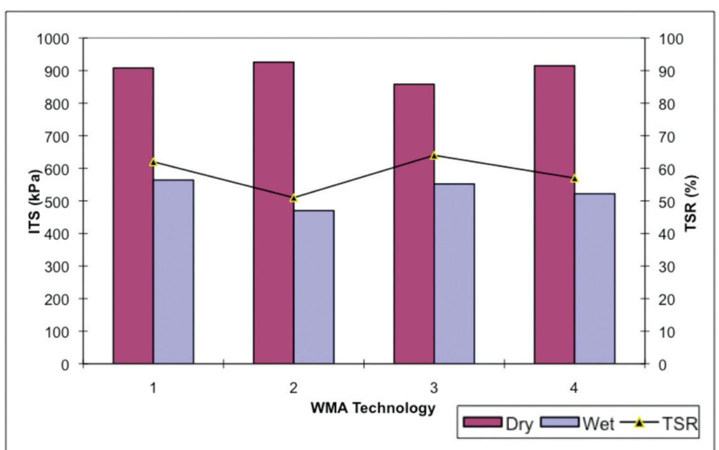


Figure 3. Summary of Laboratory Tensile Strength Ratio

HVS Testing

The HVS loaded the test sections using dual radial truck tires in a channelized, uni-directional loading mode. A temperature control chamber with infrared heaters was used to maintain pavement temperatures at 122 ± 7°F. Rutting was measured using a laser profilometer, and the failure criterion was established as an average maximum rut of 12.5 mm (0.5 inch).

The first round of testing was to assess rutting performance. Three of the four sections received between 170,000 and 239,900 equivalent single axle loads (ESALs) before failure was reached. For the remaining section, Sasobit, trafficking was terminated prior to failure at approximately 734,000 ESALs. Since the binder content of the Sasobit section was considerably lower than the other sections, the rutting

Heavy Vehicle Simulator with temperature control chamber.

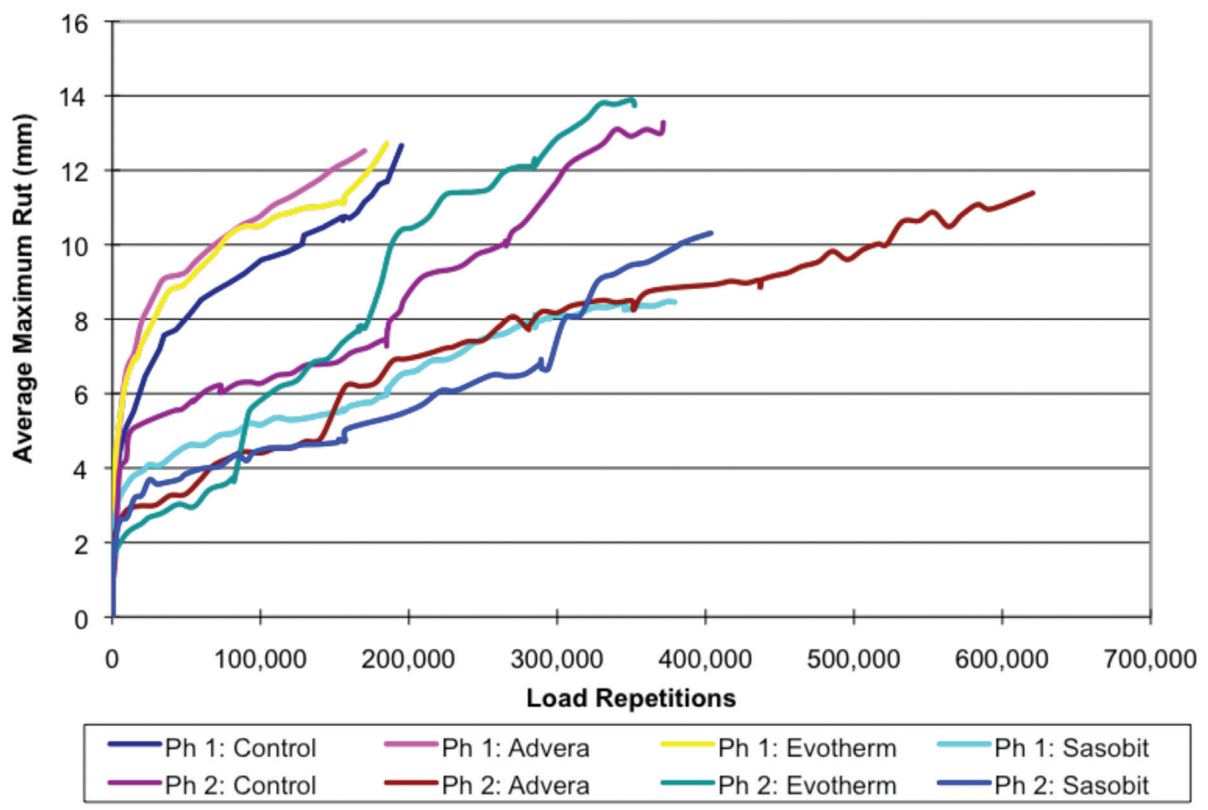


Figure 4. Comparison of average maximum rut for Phase 1 and 2 HVS testing.

performance of the Sasobit section cannot be directly compared to the remaining sections, all of which exhibited similar rutting behavior.

The second round of testing was conducted to evaluate susceptibility of the test sections to moisture damage. Each section was soaked with water for 14 days prior to loading with the HVS. During loading, a constant flow of water across the test section was maintained. Trafficking ranged from approximately 2 million ESALs on the Evotherm section to approximately 13 million ESALs on the Advera section. The control and Evotherm sections rutted at a considerably faster rate than the Advera and Sasobit sections, for which trafficking was terminated prior to failure. While the Advera and Sasobit sections received primarily full sun, the control and Evotherm sections were mostly shaded. Binder testing will be conducted to determine if different aging could be responsible for the observed difference in rutting performance. None of the sections had any sign of moisture damage, and forensic investigations confirmed that no moisture damage was present in any of the four test sections.

Rutting during HVS moisture susceptibility test

Conclusions

Despite what the lab testing indicated, no moisture damage was observed during the extreme HVS testing. The HVS tests also showed that these three WMA technologies (Advera, Evotherm DAT, and Sasobit) provide as good or better rutting performance as the control mix. "The results of this and future testing is being used to guide the implementation of warm-mix asphalt in California," says Jones.

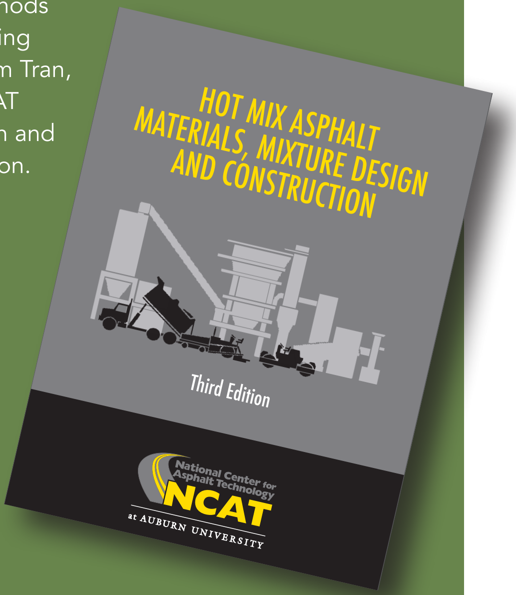
The preliminary report on this phase of the Warm Mix Asphalt Study can be found at www.ucprc.ucdavis.edu. Another phase of HVS and lab testing is underway to assess the performance of seven different WMA technologies in rubberized asphalt mixes at the UC Pavement Research Center in Davis.

Third Edition of NCAT Textbook Now Available

The third edition of "Hot Mix Asphalt Materials, Mixture Design and Construction" by E.R. Brown, P.S. Kandhal, F.L. Roberts, Y. R. Kim, D.Y. Lee and T.W. Kennedy, is now available from the National Asphalt Pavement Association (NAPA). Since its original publication in 1991, this definitive textbook has been used extensively in university courses and as an invaluable reference for those involved in the hot mix asphalt (HMA) paving industry. The third edition, completed in 2009, includes the latest information on asphalt technologies and construction practices.

Primary author Ray Brown, retired NCAT director, reviewed the entire text, adding current information on Superpave mix design, warm-mix asphalt technologies, improvements in construction methods and rehabilitation of deteriorated pavements. Richard Kim, professor of civil, construction, and environmental engineering at North Carolina State University, revised the chapter on asphalt mixture characterization to include up-to-date methods for evaluating engineering properties of HMA. Nam Tran, lead researcher for NCAT coordinated the revision and review of the third edition.

This comprehensive resource can be ordered online at http://store.hotmix.org or by phone at 888.600.4474. Quantity discounts are available.



NCAT offers a variety of training opportunities to fit your needs. To register for a class or for more information, please visit our website: www.ncat.us or call Linda Kerr at 334.844.7308 or Don Watson at 334.844.7306.

Superpave Binder Technician Training and Certification Course

The Superpave Binder Technician Training and Certification Course is a three and one-half day workshop designed to reinforce the experienced technician's skills as well as develop the knowledge and ability necessary for new technicians. The course will provide background information on the development of binder grading systems and test procedures, as well as present step-by-step descriptions of test methods used in the Superpave binder system.

Attendees will learn how to analyze test results and determine specification compliance for Superpave Performance Graded (PG) binders. They will also have the opportunity to operate the test equipment while conducting tests on samples they have prepared. Equipment used includes the rotational viscometer, dynamic shear rheometer, and bending beam rheometer. The direct tension test will also be demonstrated and tips for obtaining consistent test results will be discussed.

At the completion of the course, students will have the opportunity to take an optional Certification exam, which is recognized by many state agencies. The Certification exam is a written test (covering the test procedures and Superpave specifications) that will be given on Thursday morning between 8:00 a.m. and 12:00 noon.

This course provides 2.5 Continuing Education Units (CEUs) and will be held at NCAT facilities in Auburn, Ala.

Date: October 4-7, 2010
(Registration and payment deadline: September 24, 2010)

Cost: $800

NCAT Hosts Eurasian Road Construction Group

In March, NCAT hosted engineers and contractors from Ukraine, Moldova and the Caucasus region. They were part of the Road Construction Group visiting the U.S. through the Special American Business Internship Training (SABIT) program, which provides technical training for Eurasian business leaders and promotes partnerships between U.S. and Eurasian industry. The Road Construction Group participants attended an HMA Construction workshop and toured the NCAT lab facilities and test track.

NCAT's Asphalt Technology Course, January 25-29, 2010
Back, L-R: Jaeseung Kim (Instructor), Richard Willis (Instructor), Alessandra Bianchini (Instructor), Andrew Gall, Tyler Renton, Richard Lu, Carey Jones, Bob Fousek, Andy Tentinger, Kenny Pruitt (in hat), Devin Laubhan, Collin Sewell, Kerri Hines, Jason Mayhan, Matt Johnson, Erika Keeton, Tim Holland
Front (Kneeling), L-R: Randall Rieben, Jermaine Harton, Claro Pineda, Heather Thom, Nam Tran (Instructor), Mike Heitzman (Instructor)

NCAT's Asphalt Technology Course, February 22-26, 2010

Back, L-R: Jim Maxwell, Shawn Cook, J.C. Ray, Daniel J. Thomas, Connie Rozean-Pruitt, Mikhail Pozdnyakov, Teddy Craft, Mingjing (James) Fang

Front, L-R: Paul M. Neugebauer, Richard Willis (Instructor), John Juranek, Michael Heitzman (Instructor), Andrea Kvasnak (Instructor)

SABIT Road Construction Group visits NCAT

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