

Asphalt Technology News

In This Issue

- NCAT Marks 25 Years of Providing Research, Outreach to Asphalt Paving Industry —page 1
- Better Climate Data Produces Cost-Effective Pavement Designs —page 3
- Asphalt Forum —page 5
- Asphalt Forum Responses —page 6
- Specification Corner —page 8
- Research Roundup: Field-based Fatigue Ratios for Perpetual Pavement Design —page 9
- Research Roundup: NCAT Validates Procedure to Predict Surface Friction —page 10
- Training/Education —page 11

NCAT Marks 25 Years of Providing Research, Outreach to Asphalt Paving Industry

Leaders within the National Asphalt Pavement Association (NAPA) in the mid-80s envisioned a research center that would advance pavement technologies and improve asphalt pavement performance under increasing traffic loads. They also saw this center providing the necessary training for pavement engineers and technicians to help move new technologies into everyday practice.

The NAPA Research and Education Foundation made this vision a reality in 1986, forming a partnership with Auburn University to establish the National Center for Asphalt Technology (NCAT). Twenty-five years later, NCAT celebrates this milestone anniversary with the numerous research and outreach accomplishments

NAPA anticipated and with many more possibilities to help the industry grow.

"All our asphalt paving programs – research, outreach, educational – there may be some that are as good, but I find it hard to believe there are many better than Auburn's and NCAT's," said Dr. Paul Parks, an original member of the NCAT Board of Directors.

This article highlights the NCAT's most influential research and outreach projects since the center opened 25 years ago, with just three employees and 5,300 square feet of lab space in its original location.

Research Findings

Facilities such as the NCAT Pavement Test Track, research laboratory and field equipment have allowed NCAT researchers to develop practical and cost-effective solutions to problems facing the

asphalt paving industry. And there are still many great opportunities ahead to improve pavement performance, said Dr. Randy West, NCAT director. "As pavement engineers, we now better understand the stress states and temperatures in pavement structures, and with better lab tests to

assess asphalt mix properties under those conditions, we will be able to better explore innovative paving materials," West says.

Mix designs

NCAT has led the way in the asphalt paving industry in developing and refining innovative mix designs. For instance, test track results indicate that even high reclaimed asphalt pavement (RAP) content mixes — up to 50 percent RAP — can provide excellent rutting

performance and durability. Similarly, the track has shown that warm-mix asphalt (WMA) can be as durable and rut-resistant as hot-mix asphalt.

NCAT has also helped pavement engineers create stronger, more durable mixes by modifying stone-matrix asphalt (SMA) to align with U.S. mix design practices. SMA was originally developed in Europe. "Usually, with strength and durability, to get one you sacrifice the other," says Dr. Ray Brown, NCAT director from 1991-2007. "The technique used to design SMA gives it both qualities."

NCAT researchers have also improved the mix design procedure for open-graded friction course (OGFC), and refined Superpave mix design tests and specifications to correct some early problems that occurred with Superpave.

First NCAT Board of Directors



Seated, L-R: Dr. M. Dayne Aldridge; Dr. Paul Parks, vice chairman; Harry Ratrie, chairman; Dr. Freddy Roberts, director; and Dr. Tom Kennedy.

Standing, L-R: Charles Potts, James Tatum Jr., Michael McCartney, John Gray, Robert Hunt and Dr. Jon Epps.

—Continued from Pg. 1

New test methods

The ignition method is one of NCAT's most notable contributions to the asphalt paving industry, providing a safer, less expensive alternative to solvent extraction for determining asphalt content of plant mixes. "The NCAT furnace revolutionized that entire process," said Charlie Potts, an original member of the NCAT board of directors.

NCAT has also provided the industry with fast, efficient ways to test pavement characteristics such as surface friction. The center devised a field permeability test that is not only fast, but easy to use and transport. This method measures the drop in water level in a standpipe during a specified amount of time to determine pavement permeability.

Bond-strength testing was developed at NCAT as well. This destructive-testing procedure involves placing cores in a bond-strength loading fixture and shearing apart layers using the Marshall load frame apparatus. Interface bond strength is then calculated by dividing the maximum shear load by the cross-sectional area of the core.

Test Track

The test track has become NCAT's research centerpiece, representing about half of the center's annual research program. Brown calls the test track "our proving ground," as it unites real-world pavement construction with live heavy trafficking for rapid testing and analysis of asphalt pavements. "We can run lab tests and try to predict performance in the lab, or we can build real projects to assess new pavement technologies, but we have to wait a long time on results. The test track allows us to see the results in a much shorter time," Brown says.

The 1.7-mile track is funded and managed as a cooperative project among highway agencies and industry sponsors, who sponsor 200-ft test sections on three-year cycles. Each sponsor has specific research objectives for their section(s) and shared objectives for the track as a whole. Three cycles have been completed since the test track opened in 2000, and a fourth cycle will end this year.

"When we started the track, we were the only track in the country that could do what we're doing – compressing 15 years of wear (on the asphalt pavement) into two years," says Mike McCartney, an original member of the NCAT Board of Directors.

NCAT recently highlighted major research findings from the track in a video and accompanying brochure, both available at www.ncat.us.

Pavement structural design

One way NCAT has impacted pavement structural design is through its test track validation of mechanistic-based design models. The stress and strain measurements at the bottom of asphalt layers in track sections have correlated well with predicted values, allow the use of these models for a wide range of pavement materials and thicknesses at high speeds.

NCAT also used results of the NCAT test track to revise the asphalt layer coefficient used in pavement design, potentially saving highway agencies millions per year in construction costs. Funded by the Alabama Department of Transportation, this study examined structural test section information from past

track cycles and resulted in an increase of the asphalt layer coefficient by 18.5 percent. This translates to an 18.5 percent reduction in design thickness for new pavements.

The industry also benefits from the results of a strain threshold study on the test track, which showed that pavements can withstand higher levels of strain without accumulating fatigue damage. This allows perpetual pavements to be designed with thinner cross-sections and, thus, makes HMA more competitive against other pavement types.

Outreach

NCAT's education and training efforts have rounded out its mission to be a world-wide technical leader in the asphalt pavement community. One highlight that is cited by many people in the pavement industry is the NCAT textbook, *Hot Mix Asphalt Materials, Mixture Design and Construction*. This was the first-ever comprehensive textbook on HMA technology when initially published in 1991, and Potts says there was a pressing need for it. "If you are going to try and get students more informed in respect to HMA, you need a reference book," says Potts. "There were technical papers, but not a reference book."

A source of information for practicing engineers as well as students, the textbook has undergone two revisions since first published. The most recent version was published in 2009. "What NCAT did was not only write a good textbook, but keeps it up to date," Parks said. More than 15,000 copies of the textbook are in circulation.

Almost 1,000 people attend NCAT's training classes each year, including the annual NCAT Professor Training Course. Conducted for the first time in 1988, the course has had participants from all 50 states and countries around the world. This outreach is important because you have to thoroughly and properly train asphalt technology instructors before you can train students, Potts says. And you have to get these professors interested in making this area of civil engineering a larger part of their curriculum. "Before the Professor Training Course, the time many universities spent on HMA and asphalt pavement construction was maybe a week," Potts added. The eight-day summer course consists of intensive lectures, laboratory exercises, and discussions to investigate all phases of asphalt technology.

As a way to disseminate NCAT's research findings and training opportunities, *Asphalt Technology News* has been arriving in practicing engineers' mailboxes – and, now, e-mail inboxes – since January 1989. McCartney said that outreach efforts such as the newsletter are critical to garnering more publicity for the asphalt paving industry. "This is a very competitive market today," he added. Last year, NCAT engineers also relayed research findings and updates through the 85 technical presentations they gave at national conferences, association meetings and regional meetings.

Not all of NCAT's successful outreach efforts come in the form of a glossy publication, presentations or training courses, however. Some of NCAT's and Auburn University's biggest accomplishments are the revered leaders they've turned out to the industry, say both Dr. Brown and Dr. Parks. "We have so many great people (from Auburn) working for contractors, DOTs, and the FHWA instead of just for the university," said Dr. Brown.

Better Climate Data Produces Cost-Effective Pavement Designs

A recent study funded by the Mississippi DOT shows that the Mechanistic-Empirical Pavement Design Guide (MEPDG) is sensitive to climate inputs. “Better climate data makes a big difference in pavement performance predictions,” says Mike Heitzman, assistant director at NCAT.

The MEPDG contains limited and incomplete climate data—only 12 sites for the entire state of Mississippi, with observations covering 5 to 10 years. In order to adequately represent long-term statewide climate variations, more extensive climate data—both a denser site distribution and a broader time frame—were needed. NCAT partnered with Mississippi State University and Iowa State University’s Climate Science Initiative to generate complete 40-year historic and future climate files for the state of Mississippi and evaluate these files’ use in the MEPDG.

Building 40-year Historic Climate Files

The first step toward building 40-year historic climate files was collecting an extensive archive of available weather observations. The MEPDG requires hourly data for the following variables: air temperature, wind speed, percent sunshine, precipitation and relative humidity. For the period of interest (1970–2009), data were available from two sources:

- Automated Surface Observation System (ASOS) and Automated Weather Observation System (AWOS)—These programs are maintained by government agencies and report a variety of hourly data, however, locations are limited primarily to airports, and the data is subject to errors and gaps in information. For this study, data from neighboring states’ ASOS/AWOS sites was also gathered to aid in the analysis.
- Cooperative Observer Program (COOP)—These observation sites, administered by the National Weather Service, are relatively dense compared to ASOS/AWOS. However, while the data is high quality, it is limited to daily high/low temperatures and precipitation totals.

Not every county within Mississippi has both an ASOS and a COOP site. Thus, a grid was constructed, with a grid spacing of approximately 25 km, so that there was roughly one grid point per county. The analysis procedure used natural neighbor interpolation, a spatial interpolation technique that weighs the relative contribution of surrounding observation sites on a particular point of interest. Separate analyses were performed for the hourly ASOS/AWOS data and the daily COOP data.

For each county, hourly values from the grid point closest to the centroid of the county were compiled. Temperature and precipitation values were also adjusted to include the higher-quality COOP data while maintaining the hourly variability determined using ASOS/AWOS data. An example is shown in Fig. 1, in which an observed temperature curve (based on ASOS/AWOS data) is shifted to match the corresponding COOP high and low temperatures. In this manner, complete 40-year historic climate files were generated for each county within the state. These historic climate files are critical in matching climate characteristics with pavement data used in local MEPDG calibration.

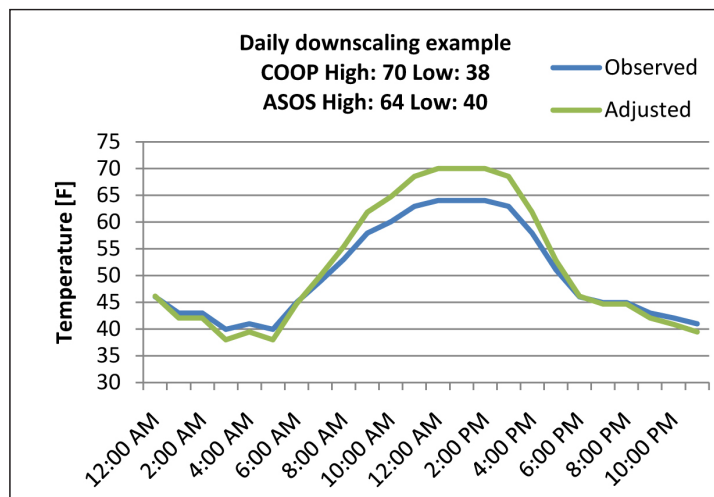


Figure 1 Shift in temperature curve to reflect more accurate COOP data.

Building 40-year Future Climate Files

Well-constructed future climate scenarios aid in evaluating the impact of expected climate change on pavement performance. Global climate models, which reflect rising levels of greenhouse gases within the atmosphere, provide large-scale results (typically one grid point per 35,000 square miles). Dynamical downscaling is then used to refine the results spatially by means of a regional climate model. This study used the regional climate model RegCM2, with a grid-point spacing of about 80 miles.

Historic temperature and precipitation data is influenced by cyclic weather phenomena such as El Niño and La Niña, as well as major weather events such as hurricanes. However, the global climate model does not reflect these important influences on climate variability. This problem was addressed by first creating two proxy climate scenarios, using the global and regional models—a contemporary climate representing the 1990s and a future climate representing the 2040's. Both scenarios had realistic seasonal and daily temperature variations, but when compared with recorded historic data, the contemporary model reflected a systemic bias of $\pm 1\text{--}2^\circ\text{C}$. Assuming the bias was similar for both scenarios, subtracting the contemporary values from the future values (which were higher due to increasing greenhouse gases) resulted in eliminating or greatly reducing the bias. The difference in future and contemporary temperature values—and likewise, the ratio of future to contemporary precipitation—for each grid point and each month resulted in climate deltas. These climate deltas were then applied to the historic climate values. In this manner, the 40-year future climate file reflected both the predicted climate change

Well-constructed future climate scenarios aid in evaluating the impact of expected climate change on pavement performance.

—Continued on Pg. 4

—Continued from Pg. 3

due to increased greenhouse gases (climate deltas obtained from global and regional models), as well as the influence of cyclic and extreme weather events (from the historic values).

Impact on Pavement Performance Prediction

The effect of climate data on MEPDG pavement performance predictions was then evaluated. Several pavement designs were assessed using the 40-year historic climate scenario, the 40-year future climate scenario and the MEPDG climate data. Although differences were also observed in cracking and IRI predictions, the most dramatic differences were seen in rutting predictions. The following rut prediction examples are based on a thin (4.5 inch) hot-mix asphalt (HMA) design.

In Figure 2, the difference between predicted 20-year rutting using the MEPDG climate data and the 40-year historic climate data is shown for each climate zone in Mississippi. For each zone, the rutting difference is positive, indicating that predicted rutting is higher when using the MEPDG climate data. Thus, using the MEPDG climate data would result in overdesign of the pavement structure, either in terms of thickness or quality of materials.

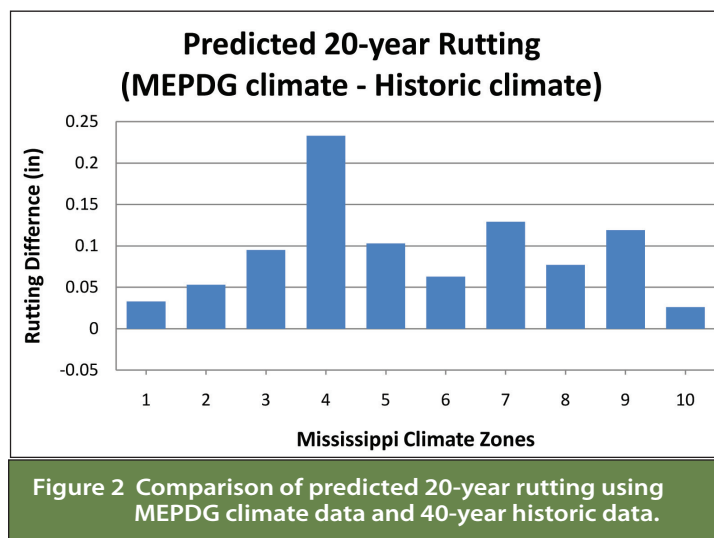


Figure 2 Comparison of predicted 20-year rutting using MEPDG climate data and 40-year historic data.

As shown in Figure 3, the differences between 20-year predicted rutting using the 40-year historic and future climate scenarios are almost negligible. The negative values indicate that the virtual (future) climate input, which predict increased temperatures, resulted in slightly higher rutting predictions than the historic data. However, the magnitude of the differences was small, indicating that similar results are obtained whether using the historic climate data or the more labor-intensive future climate scenario.

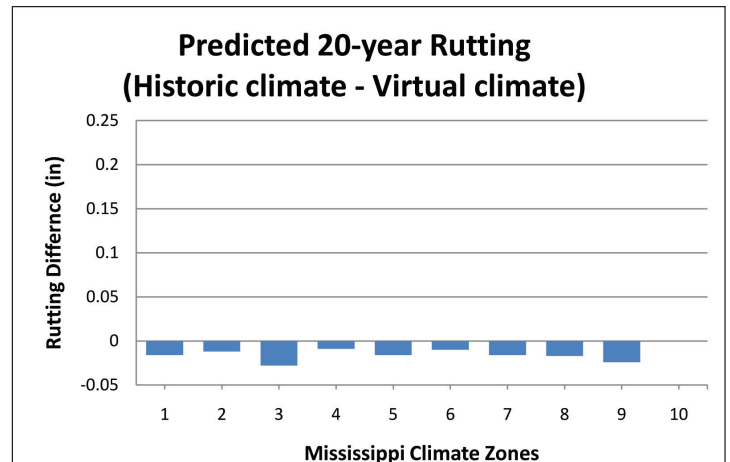


Figure 3 Comparison of predicted 20-year rutting using historic and virtual (future) climate scenarios.

Figure 4 shows the predicted rutting throughout a 40-year period for Mississippi's Zone 4 using all three climate data sets. While predicted rutting is similar for the historic and future climate scenarios, there is a substantially higher predicted rutting using the MEPDG climate data. Better climate data, such as the 40-year historic climate file developed in this study, results in more reliable rutting predictions, which translates into a more cost-effective pavement design.

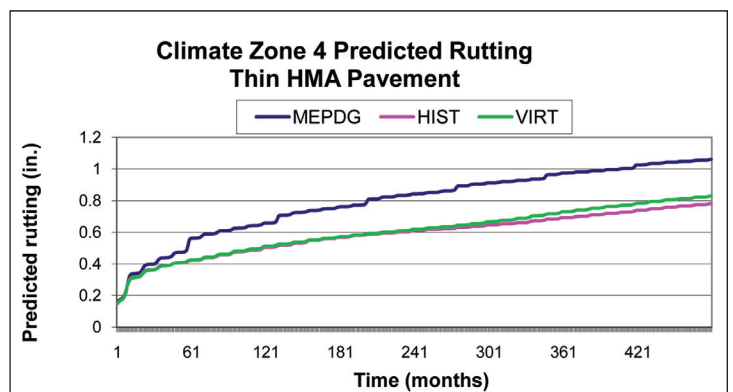


Figure 4 Predicted rutting for Zone 4 using MEPDG, historic and virtual (future) climate data sets.

For more information on this study or if you are interested in pursuing a similar study for another state or region, please contact Mike Heitzman at 334.844.7309 or mah0016@auburn.edu.

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

Allen Myers, Kentucky Transportation Cabinet

Asphalt contractors in Kentucky placed approximately 980,000 tons of warm-mix asphalt (WMA) in 2010. Of this amount, about 90 percent was produced with water-injection/asphalt foaming systems. Currently, 18 asphalt mixing plants that supply to Kentucky have been approved for WMA production with this technology. The remaining 2010 WMA tonnage consisted of experimental projects involving wax and chemical additives. The Kentucky Transportation Center at the University of Kentucky is conducting a research study evaluating WMA production, placement and performance.

Mark Woods, Tennessee Department of Transportation

It would be interesting to hear how other states approve hot-mix asphalt (HMA) designs prior to production. More specifically, what materials are submitted/tested (if any), and what is the department ultimately trying to evaluate?

Greg Sholar, Florida Department of Transportation

Has any agency used bonded wearing courses (i.e., Novachip process) and seen a noticeable improvement in performance?

Has any agency experienced problems with end-of-load segregation and, if so, how is this being rectified?

Has any agency placed asphalt wearing courses with PG 82-22? If so, were compaction aids like Sasobit added? Were there any issues with construction?

Don Watson, NCAT

Have any agencies implemented the multiple stress creep recovery (MSCR) test for asphalt binders? Has the test eliminated any binders that would otherwise be acceptable?

Have any agencies investigated the recyclability of asphalt-rubber mixtures manufactured with ground tire rubber? Have any environmental studies been conducted to evaluate plant emissions where ground tire rubber has been used in mixture production?



In December 2010, asphalt plant technicians from Hurlburt Air Force Base in Florida attended a custom-tailored course on military projects at NCAT. The course involved both classroom lectures and hands-on laboratory testing.

Asphalt Forum Responses

The following responses have been received to questions shared in the Fall 2010 Asphalt Forum.

1. Are any states using asphalt rubber binder (ARB) as a substitute for styrene-butadiene-styrene (SBS)? (Randy Mountcastle, Alabama Department of Transportation)

The Ohio and Tennessee DOTs both reported that they do not use ARB as a substitute for SBS.

Dale Rand, Texas Department of Transportation

We do not specifically call out SBS as the modifier. The Wright Asphalt TR process can be used. Traditional asphalt rubber (AR) binder had not been used as a direct substitute for SBS.

Greg Sholar, Florida Department of Transportation

FDOT does not substitute ARB for SBS. It is in the initial phases of evaluating ARBs manufactured in various ways, all meeting PG 76-22 requirements except for the solubility test, and will conduct high-performance rutting and laboratory tests.

2. Do any states use a double-layer open-graded friction course (OGFC)? (Randy Mountcastle, Alabama Department of Transportation)

The Ohio, Tennessee, Texas and Florida DOTs all reported that they do not use a double-layer OGFC.

3. We are developing wording to address sample custody in all of our future HMA specifications. The FHWA is particularly concerned about how we handle roadway cores to ensure that the opportunity for fraud is minimized or eliminated. We are not aware of any fraudulent activity; however, as a result of fraud in some other parts of the country, this has become a high priority to the FHWA. We rely on the contractor to obtain the cores from the roadway and in some cases deliver them to our lab at the HMA production facility, which can be located an hour or two from the job site. We currently do not have a system in place that would ensure the cores could not be switched or altered in some way. We are exploring several ideas on how to address this situation in an effort to come up with something the FHWA will buy off on. Our situation, like many others, is that we typically have only one inspector available on the project, and this inspector cannot take off several hours to deliver cores to our testing lab. In the past, we instructed the contractor (actually the truck drivers) to transport these cores for us, but we have been informed by the FHWA (who is reviewed by the Office of Inspector General [OIG]) that we can no longer continue this practice. This all came to light when the OIG started reviewing stimulus projects in Texas.

We would like to know if any other states are facing a similar situation and, if so, what is your proposed solution? (Dale Rand, Texas Department of Transportation).

David Powers, Ohio Department of Transportation

While we share concerns over sample handling, we do not rely on contractors for core delivery. Contractors take cores and pass them to project personnel. If our project personnel perform their roles correctly, the location, taking and handling the cores are all verifiable by ODOT personnel. Samples taken at plants out of trucks are within contractor control. We have a verification process that triggers specific responses if samples do not match the contractor and the JMF. We rarely see verification issues.

Greg Sholar, Florida Department of Transportation

We handle cores very similarly to Texas DOT. We are experimenting with stencils that have unique configurations. Spray paint will be applied to mark the pavement surface with this unique pattern prior to cutting the cores from the pavement. Though it is not fool-proof, it is one extra step to minimize the likelihood of core substitution.

Allen Myers, Kentucky Transportation Cabinet

For the past three to four years, the custody of density cores has been a major issue in Kentucky. Like Texas, contractors in Kentucky obtain the cores from the roadway. Our specifications require the contractor to immediately provide the cores to the cabinet representative at the coring site. The cabinet inspector is responsible for transporting the cores to the laboratory for testing by cabinet technicians. Our specifications also require us to report the density results to the contractor within two working days.

4. AASHTO T 168/ASTM D 979 procedures for sampling HMA from a truck transport require taking samples at random from the truck in approximately three equal increments and combining them to form one representative sample. Some of the large truck beds in use today make this virtually impossible without the technician having to climb into the truck bed. How are states addressing this issue of getting random, representative samples from large truck beds without compromising the safety of the technician? (Don Watson, NCAT)

—Continued on Pg. 7

—Continued from Pg. 6

David Powers, Ohio Department of Transportation

Ohio DOT allows the use of sampling devices. Their use is growing. However, the concern over technicians in trucks still exists.

Dale Rand, Texas Department of Transportation

This is an issue. We require taking the sample from multiple locations in the truck bed without walking or standing on the HMA. The technicians take the samples with a shovel from a sampling rack. In most cases, they just do the best they can. The contractor representative is required to obtain most of the samples, so if the sample is “not representative” it falls under the contractor’s responsibilities.

Greg Sholar, Florida Department of Transportation

The FDOT is treating these larger trucks the same way as smaller trucks. Technicians are not climbing into the trucks.

5. **Most agencies specify that the HMA mixture temperature be within a certain tolerance of that specified in the mix design or job mix formula for the project; otherwise, the mix may be rejected. Has anyone conducted research to show that mix produced at temperatures lower than the allowed tolerances is detrimental to HMA quality and long-term performance? How critical is the specified mix temperature if a contractor uses a materials transfer device to remix the material at the roadway to a uniform temperature and is able to meet the specified target density and smoothness requirements? (Don Watson, NCAT)**

David Powers, Ohio Department of Transportation

For large jobs with established compaction and roller trains, we do not see the temperature requirements as a big issue. This is where MTVs would work well. However, we see issues with inconsistency in compaction on small projects and night projects. As such, we maintain temperature requirements for polymer binder mixes and require MTVs for night work.

Dale Rand, Texas Department of Transportation

We allow the mix to be produced (with or without WMA additives) at temperatures between 215°F and 350°F. Thermal segregation is the biggest concern at lower temperatures. With certain WMA additives, this is not an issue. With conventional mix (no WMA additive), we typically see coating issues with mix produced below 275°F.

Greg Sholar, Florida Department of Transportation

FDOT has done limited research and shown the effects of density related to temperature drop, but it has not done any performance testing.

6. **For agencies that have implemented percent-within-limits (PWL) specifications for HMA acceptance, what were the greatest challenges to implementation? How did you overcome those challenges? (Don Watson, NCAT)**

David Powers, Ohio Department of Transportation

We have not implemented PWL due to a very large number of smaller tonnage projects in which the number of data points is too low to be statistically valid. We do not see the logic or value in having a dual system (one for small projects and PWL for large projects).

Greg Sholar, Florida Department of Transportation

The greatest challenges were education; determining accurate PWL upper and lower limits; and modifying specifications, forms, etc. This effort took years to implement and refine and needed the cooperation of everyone involved. Hiring a consultant would be helpful in the initial stages. FDOT is pleased with the resulting system and believes we have a better asphalt product than before PWL specifications.

7. **What changes are agencies anticipating or planning to make in order to meet the new FHWA regulations on noise? Do quieter pavements fit into those plans? (Don Watson, NCAT)**

Andy Gisi, Kansas Department of Transportation

The new FHWA regulations on noise, 23 CFR Part 722: Procedures for Abatement of Highway Noise and Construction Noise, exclude pavements specifically from methods to reduce noise. The following is an excerpt from the register:

“While the FHWA recognizes the efforts of many State highway agencies and the pavement industries, there are still too many unknowns that currently prohibit the use of pavement as a noise abatement measure.”

I don’t believe the State Highway Agencies (SHA’s) need to do anything to make its pavements quieter. There are some efforts by the SHAs to provide more information that can be used in the traffic noise model (TNM), but states cannot modify the TNM based on their data alone.

Greg Sholar, Florida Department of Transportation

FDOT’s Environmental Office, in conjunction with the Materials Office, is contracting research to have FDOT included in FHWA’s Quiet Pavements Program. This research has been in progress for several years and is not complete.

Ohio

We have just implemented specifications that allow tear-off shingles. We had allowed shingle manufacturing waste for more than 12 years. Details can be found at our website: <http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Pages/ProposalNotesSupplementalSpecificationsandSupplements.aspx>. (Note: Supplemental Spec 800 contains section 401.04 material requirements, and Supplemental Specification 1116 covers recycler requirements.) We have updated post-blended SBR latex plant injection requirements to include automated equipment requirements. See Section 402 in the above link for Supplemental Spec 800.

Tennessee

Tennessee is currently discussing removing its "AC content for bidding purposes," which requires bidding HMA contractors to bid all mixes of each type at a specified predetermined AC content. Once produced, pay items are adjusted for the actual design/produced AC content and indexed. The department is currently discussing the potential effects of removing this requirement and allowing contractors to bid at their design AC values.

The department is also discussing tightening its pay factor tables for gradation and asphalt content to encourage even more consistent production.

Texas

In January 2011, the Texas DOT approved a special specification (SS 3224) that replaces the standard hot-mix Item 341, which comprises approximately 75 percent of the HMA placed in Texas. This special specification is a culmination of other special provisions to Item 341. Some of the highlights of the new special specification (SS3224) are as follows:

- Allows the use of RAP and RAS on all projects and sets maximum amounts of recycled asphalt binder that can be used in each mixture.
- Allows the use of WMA on all projects.
- Allows the use of "Substitute Binders" on all projects. (Note: This provision allows a contractor to use, for example, a PG 64-22 in lieu of a PG 70-22 provided the mixture meets all specification requirement, such as Hamburg Wheel, etc., for the originally specified binder grade.)

SS 3224 also addresses sample custody issues. It requires that all samples (specifically roadway cores) be placed in "security bags" if the samples are ever out of the engineer's possession. (Note: Texas DOT worked with a vendor to develop custom security bags.) The bags have a unique ID number on the inside and once sealed cannot be opened without damaging the bags. SS 3224 also provides incentives for contractors to use the Pave-IR system to measure thermal segregation. SS 3224 will be used as the template for the Texas DOT to rewrite all remaining HMA specifications (Superpave, SMA, PFC, etc).

Kentucky Transportation Cabinet

The Kentucky Transportation Cabinet is currently reviewing its Standard Specifications in preparation for a new manual in 2012. The following are some changes being considered for the asphalt area:

- Update the section involving reclaimed asphalt materials. Add requirements for reclaimed asphalt shingles. Use the concept of "effective asphalt binder content replacement" (by the reclaimed materials) for determining the appropriate grade of virgin asphalt binder.
- Allow a maximum of 10 percent reclaimed asphalt pavement in stone-matrix asphalt.
- Formally adopt the requirements for material-transfer vehicles.



AMPT Training Update

The next National Highway Institute (NHI) Asphalt Mixture Performance Tester (AMPT) course is scheduled at NCAT this year on May 3-4.

Left: NCAT engineer Brian Waller leads an NHI AMPT Training Course in February 2011.

Field-based Fatigue Ratios for Perpetual Pavement Design

Perpetual pavements are designed and built to last for more than 50 years, requiring only a periodic mill and inlay of the surface layer. The benefits of building such long-lasting pavements include low life-cycle costs, low user-delay costs and reduced environmental impacts. One aspect of designing perpetual pavements is the prevention of fatigue cracking by limiting the horizontal strain at the bottom of the hot-mix asphalt (HMA) layer. An appropriate strain or fatigue endurance limit must then be determined so that the pavement structure can be cost-effectively designed to avoid fatigue damage.

Laboratory tests, such as the bending beam fatigue test, generally underestimate fatigue life in the field. Thus, engineers apply a shift factor, ranging from four to 100, to better relate lab results to field fatigue life. A commonly used fatigue threshold for flexible pavement design is 70 microstrain, a value based on laboratory testing at one temperature. However, results from the NCAT Pavement Test Track have shown that pavements can withstand higher strain levels in the field, indicating that flexible pavements can be designed thinner without sacrificing fatigue life.

Structural sections from the 2003 and 2006 test track cycles have provided pavement response and performance data to aid in determining field-based strain criteria for perpetual pavement design.

2003 Fatigue Study

Two asphalt base mixtures from the 2003 test track cycle were evaluated in the laboratory using the bending beam fatigue test, AASHTO T 321, to determine their fatigue endurance limits. The mixes were identical except for binder grade and were placed in seven structural sections, with total HMA thickness varying from five to nine inches. A total of 10 million equivalent single-axle loads (ESALs) were applied in the two-year research cycle. During that time, pavement strain data were collected through embedded instrumentation and weekly performance surveys were conducted.

Initial attempts to relate laboratory fatigue thresholds and field-measured strains were unsuccessful. In the first analysis, field-measured strain-temperature relationships were developed to compare field strain at 20°C—the temperature at which lab beam fatigue testing is conducted—to the lab fatigue endurance limit. However, no clear relationship could be determined. A second analysis technique involved superimposing the lab fatigue endurance limit on cumulative strain distributions from the start of trafficking until fatigue cracking became evident. Although it would seem that sections with a higher percentage of strain events below the lab fatigue endurance limit would be more fatigue-resistant, this was not always the case. As seen in Fig. 1, sections N2 and N6, both of which experienced cracking, had higher percentages of strain events below the fatigue threshold than section N3, which did not crack. However, it was observed that sections with fatigue cracking had wider strain distributions, and thus, higher overall strains, than sections that did not crack.

A third attempt to relate laboratory fatigue thresholds and field-measured strains gave much better results. This method compared the entire cumulative strain distribution to the laboratory-determined fatigue threshold, using the concept of fatigue ratios. A fatigue ratio at a given percentile is defined as the ratio of strain at that percentile to the lab

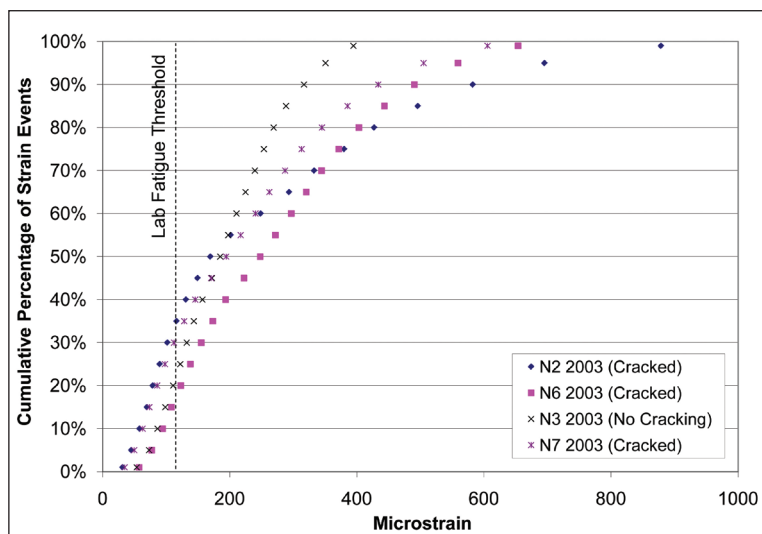


Figure 1 Cumulative strain distributions and fatigue threshold for 2003 PG 67-22 base mix.

fatigue threshold. Among the 2003 structural test sections, a divergence was observed between the fatigue ratios of sections with fatigue damage and those without. From the 60th to the 99th percentile, the fatigue ratios of sections that cracked were distinctly higher than those that did not crack.

2006 Fatigue Study

Eleven sections—varying in HMA thickness from 7 to 14 inches and including a range of mixtures—comprised the 2006 structural study at the test track. Of the 11 sections, six were new construction. Sections N3, N4, N6 and N7 remained in-place from the previous cycle of testing, while the existing section N5 received a two-inch mill and inlay to mitigate top-down surface cracking. As trafficking progressed, the strain analyses were discontinued for two of the new sections due to cracking; the distress was later shown to be surface cracking, not fatigue-related.

Beam fatigue testing was conducted for each of the three new base mixtures. Six beams were compacted for each mixture at an air void content of 5.5 percent to reflect the in-place density of the mixes placed on the track. This differed from the 2003 beam fatigue testing, in which the specimens were compacted to 7 percent air voids. The beams were tested at 20°C and a frequency of 10 Hz; half of the specimens were tested at a controlled strain of 800 $\mu\epsilon$, and the other half were tested at 400 $\mu\epsilon$. While the two base mixes from 2003 had similar fatigue results in the lab, the lab fatigue results among the 2006 base mixes were much more diverse.

Field-measured strains were collected through embedded pavement instrumentation. The analysis excluded strain readings after evidence of fatigue damage for any section, as a pavement structure ceases to be perpetual when fatigue cracking occurs.

As with the analysis of the 2003 data, no clear relationship was found between the laboratory fatigue endurance limit, field strains at a

—Continued on Pg. 10

—Continued from Pg. 9

normalized temperature and field performance. The second analysis technique, superimposing the lab fatigue endurance limit on the field cumulative strain distribution, yielded results that were more intuitive than with the 2003 data but were impractical as design criteria. As with the 2003 study, the fatigue ratio concept proved to be the most successful means of relating lab and field fatigue results.

Percentage of Strains during the Design Period	Maximum Fatigue Ratio
99%	2.83
90%	2.18
80%	1.85
70%	1.63
60%	1.44
50%	1.27

Table 1 Proposed fatigue control points for perpetual pavement design.

Recommendations

Rather than a single limiting strain criterion, the researchers recommend maximum-allowable fatigue ratios, shown in Table 1, for perpetual pavement design. The analysis included multiple sections from the 2003 and 2006 cycles that did not experience fatigue cracking. These limits reflect the section that had the highest fatigue ratios.

These results are based on laboratory fatigue testing of beams compacted to 7 percent air voids. The maximum fatigue ratios can be used to determine an allowable strain distribution by multiplying the fatigue ratio by the 95th percentile confidence interval lower-bound endurance limit for a mixture. Further analysis of the fatigue ratio concept is being conducted using base mixtures from the 2009 test track.

For more information, view the full report, *Field-Based Strain Thresholds for Flexible Perpetual Pavement Design* (NCAT Report 09-09, Willis and Timm), which is available for download at www.ncat.us.

NCAT Validates Procedure to Predict Surface Friction

Pavement surface friction, or skid resistance, is an important concern for highway agencies. Highway user safety depends on it. Over time, repeated abrasion from traffic can cause aggregate polishing and changes in surface texture, resulting in a decrease in surface friction. To ensure adequate skid resistance throughout the life of a pavement, agencies use conservative engineering judgment when specifying high-quality friction aggregate for surface layers.

A rapid means of evaluating friction characteristics of surface mixtures has been needed so agencies can optimize aggregate blends as part of mix design. NCAT developed the Three-Wheel Polishing Device (TWPD), which conditions the surface of pavement slabs. The polished slabs are measured for friction loss using the Dynamic Friction Tester (DFT), according to ASTM E 1911, and changes in surface texture are measured using the Circular Texture Meter (CTM), according to ASTM E 2157.

As seen in Fig. 1, the NCAT TWPD has three pneumatic rubber tires (each inflated to 50 psi) that rotate in an 11.2-inch diameter circle. Wheel-

loading can be changed by adding or removing circular steel plates on top of the turntable, and rotation speed is also adjustable. Water is recirculated through a spray system that washes away abraded particles from the surface of the HMA slab. DFT and CTM measurements are taken at prescribed intervals during the polishing process. Complete testing can be completed within three to 10 days per slab.

Refining and Validating the Polishing and Testing Process

The study included two phases with the following objectives:

- Phase I—Refine the lab testing protocol for the TWPD and determine the optimum load and speed combination.
- Phase II—Evaluate friction characteristics of mixtures containing different proportions of friction aggregate and correlate lab and field results.

Phase I evaluated the TWPD using three loads (91, 107 and 122 lbs) and two speeds (40 and 60 rpm). Two stone matrix asphalt (SMA) mixes were used—Mix A with high friction performance at the NCAT Pavement Test Track and Mix B with low friction performance. Both mixes contained primarily limestone aggregates. Three replicate specimens of each mix and for each load/speed combination—a total of 36 slabs—were tested using the TWPD, DFT and CTM to determine the optimum load and speed combination for the TWPD.

Phase I testing showed that the lowest load (91 lbs) polished the HMA surface more than the higher loads. The lighter load allowed the pneumatic tires to slip on the HMA surface more often than higher loads, thus providing a higher level of polishing. The data showed that the speed of the polishing carriage was not a factor, so the 60 rpm speed was selected to reduce the testing time.

Phase II evaluated two dense-graded mixes—Mix C, exhibiting high

—Continued on Page 11



Figure 1 NCAT Three-Wheel Polishing Device.

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

NCAT Hosts Three-Week Workshop for Russian Engineers

As a leading organization in hot-mix asphalt (HMA) technology, the National Center for Asphalt Technology (NCAT) was asked to conduct a three-week workshop for Russian engineers in HMA materials engineering, pavement design, HMA construction and pavement performance. The goal of the workshop, held March 14-April 1, 2011, was to improve the knowledge and competencies of process-engineering personnel in the development, production and testing of HMA road-building materials. The workshop was sponsored by The Russian Corporation of Nanotechnologies, located at I.V. Kragelskiy Institute of Tribology (ITRIB).

NCAT lead engineers covered topics such as:

- Types of asphalt binders and production methods
- Rheological properties of asphalt binders and test methods
- Structural and mechanical properties of asphalt-concrete
- Structural design methods for increasing asphalt-concrete flexibility and durability
- Introduction to nanotechnology
- Standardized testing and inspection of road construction materials
- Evaluation of modern manufacturing technology of road construction materials



Left side, standing, L-R: Igor Igoshin, interpreter; Jason Moore, instructor; Ekaterina Kiseleva; Alexander Sinelnikov; Viacheslav Khovanskiy, head of group; and Zverev Alexander.

Front, kneeling, L-R: Ilya Shkatulov; Alexey Korotkov; Basov Sergey; Jason Nelson; instructor; Alexander Ushkov; and Don Watson, instructor.

Right side, standing, L-R: Anna Belcheva, Nisimov Stanislav, Kirill Kuzin; Kolosov Ilya, Denis Overin; Alexander Vinopal, Elena Sobchenko, and Kochnev Vladimir

- Demonstration of standard and research laboratory equipment to test the components and performance of HMA materials
- Accelerated pavement testing

The workshop also included a tour of East Alabama Paving and the NCAT Pavement Test Track.

—Continued from Pg. 10

friction performance at the test track, and Mix D that had lower friction performance. Mix C contained primarily granite, while Mix D contained limestone. Additional aggregate blends were prepared for each mix, varying the percentages of granite and limestone to decrease or increase the amount of friction aggregate. Three replicates of each mix and each additional aggregate blend (18 slabs altogether) were evaluated using the refined TWPD protocol determined in Phase I.

As expected, Phase II results revealed that DFT friction values decreased as the amount of friction aggregate was decreased in Mix C. However, no clear trend was observed for Mix D (which had lower friction characteristics) as the amount of friction aggregate increased.

Correlation of Lab Friction Results with Field Measurements

The laboratory friction data at periodic intervals for the four mixes were correlated with test track field friction measurements using the Locked Wheel Skid Trailer (LWST) according to ASTM E 274.

Figure 2 displays the correlation between the lab and field data. The results clearly show that the laboratory TWPD test protocol can be used

to predict HMA surface mixture friction performance for a diverse set of mixtures. The laboratory test has time, cost and safety advantages over traditional open-road test section evaluations.

For more information, contact Dr. Mike Heitzman at NCAT (mah0016@auburn.edu).

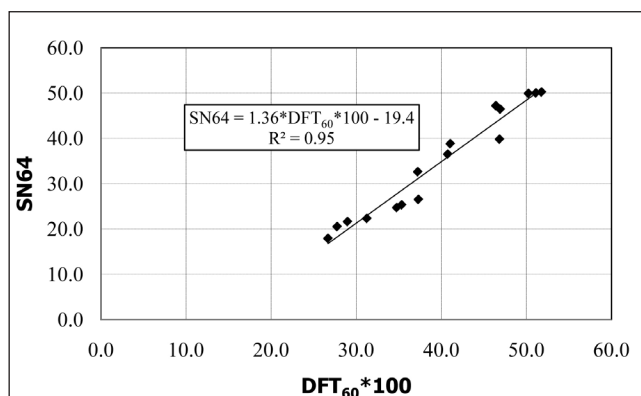


Figure 2 TWPD friction correlation to test track friction.



at AUBURN UNIVERSITY

735 Extension Loop, Auburn, AL 36849-7350

Nonprofit Org.
U.S. Postage
PAID
Permit #9
Auburn, AL 36849

National Center for Asphalt Technology,
277 Technology Parkway, Auburn, Alabama 36830-0550
Phone: 334.844.NCAT (6228) Fax: 334.844.6248

Randy West, Director, NCAT
Karen Hunley, Editor, NCAT
Courtney Jones, Writer, NCAT
Cheryl Cobb, Associate Editor, College of Engineering

ASPHALT TECHNOLOGY NEWS (Library of Congress Catalog No. ISSN 1083-687X)
is published by the National Center for Asphalt Technology (NCAT) of Auburn University. Its purpose is to facilitate the exchange and dissemination of information about hot mix asphalt technology, trends, developments and concerns. Opinions expressed in this publication by contributors and editors, the mention of brand names, the inclusion of research results, and the interpretation of those results do not imply endorsement or reflect the official positions or policies of NCAT or Auburn University.