

Asphalt Technology News

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Good Performance of Sustainable Materials, Construction Practices Highlight Fourth Track Cycle

NCAT hosted the fourth Pavement Test Track Conference in February, highlighting how the test track helps turn theory into practice and enables transportation agencies to do more with less. Along with presentations from NCAT researchers, the conference also featured representatives from sponsoring agencies, who discussed how longer-lasting, safer, more economical roads are the direct result of implementing test track research.

The fourth research cycle began in 2009, when 17 of the track's 200-ft. test sections were either reconstructed or rehabilitated, while the remaining 29 sections were left in place to allow for additional traffic loading. Trafficking began in August 2009 and ended in September 2011 after 10 million equivalent single axle loads (ESALs) were applied. "The timing of fleet operations was very important, so that the 25-month testing cycle included three summers," says Dr. Buzz Powell, NCAT's assistant director and manager of the test track.

Some test sections were built on thick pavement foundations to ensure that surface distresses would be materials-related; other sections had varied asphalt layer thicknesses with embedded instrumentation to measure pavement response to traffic loading. For all sections, pavement performance was quantified on a weekly basis with regard to smoothness, rutting, raveling and cracking. Objectives for each individual test section and the track as a whole were decided by highway agency and industry sponsors, with economic and environmental sustainability as top priorities.

High RAP Mixes

Mixes with up to 50 percent RAP have performed successfully at the test track, providing excellent rutting resistance and durability. Two structural sections containing 50 percent fractionated RAP were placed in 2009 as part of the Group Experiment—one mix was conventional hot-mix asphalt (HMA) and the other was warm-mix asphalt (WMA) produced using a water-

injection foaming process. Both sections used unmodified PG 67-22 binder, whereas the control section contained all-*virgin* materials and polymer-modified PG 76-22 binder in the top two layers. After 10 million ESALs, both high-RAP sections performed as well as the control, with minimal rutting, very small changes in smoothness and texture, and no

observed cracking. The increased stiffness of the high-RAP mixes resulted in lower critical tensile strains and subgrade pressures relative to the control.

Four sections with 45 percent RAP were left in place from the previous cycle of testing, accruing a total traffic loading of 20 million ESALs. These sections compared different *virgin* binder grades (PG 52-28, PG 67-22 and PG 76-22). All four sections had exceptional rutting performance, with rut depths less than 5 mm after two cycles of trafficking that

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Dr. Dave Timm, Brasfield and Gorrie Professor of Civil Engineering at Auburn, gives a tour of structural sections of the 2009 test track during the NCAT Pavement Test Track Conference.

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included some of the hottest recorded summers for the local area. Mixes containing stiffer virgin binder grades exhibited minor cracking at an earlier stage than mixes with softer binders, indicating that a softer virgin binder grade slightly improves the durability of high-RAP mixes.

In 2009, Mississippi DOT also sponsored a section containing 45 percent RAP. While the mix used PG 67-22, early results indicate that performance is similar to an all-virgin mix with polymer-modified PG 76-22. Significant cost savings can be achieved by using high-RAP contents combined with unmodified binder.

Warm-mix Asphalt

In addition to the WMA test section with 50 percent RAP, two structural sections comparing WMA technologies—water-injection foaming method and a chemical additive—were also constructed at the test track as part of the 2009 Group Experiment. After the application of 10 million ESALs, rut depths were satisfactory in both WMA sections, though slightly higher than in the control section, probably due to less binder aging and absorption during production. There were few practical differences between the WMA sections and the control with regard to structural response, according to Dr. David Timm, Brasfield and Gorrie Professor of Civil Engineering at Auburn University. No cracking was evident in either section, and lab test results indicated greater fatigue life expectations for the WMA sections relative to the control.

Alternative Binders and Binder Modifiers

Several alternative binders and binder modifiers were evaluated during the 2009 research cycle, investigating ways to reduce the quantity of asphalt materials needed for construction. Two options—Shell Thiopave, a warm-mix sulfur technology, and Trinidad Lake Asphalt, pelletized natural asphalt imported from Trinidad and Tobago—were successfully used as partial replacements for refined liquid asphalt in three test sections.

Kraton Polymers also sponsored a structural section incorporating highly polymer-modified (HPM) mixes that were very stiff but strain-tolerant, allowing the test pavement to be designed with an 18 percent thinner cross-section. The excellent fatigue and rutting resistance observed in this section made HPM the material of choice in rehabilitating a nearby pavement section that was completely failed.

Other experimental sections at the test track compared binder modification with ground tire rubber (GTR) and styrene-butadiene-styrene (SBS) polymer. Both laboratory testing and field measurements showed that mixes containing GTR performed comparably to SBS mixes in every way.

Porous Friction Courses and Stone Matrix Asphalt

The benefits of porous friction courses (PFCs) include improved surface friction characteristics, reduced tire spray during rain events and reduced noise from tire/pavement interaction. However, since the structural value of PFCs was unknown, some states attributed no structural contribution at

all to PFC layers. Embedded instrumentation at the test track allowed for the structural characterization of a PFC section, indicating that PFCs do contribute to a pavement's overall structural integrity. A provisional structural coefficient of 0.15 was determined for PFCs, allowing states to optimize pavement designs and make full use of available resources.

As a rehabilitation surface in another section, PFC extended the performance life of underlying dense mix with a history of cracking susceptibility. Performance was further improved when the PFC surface was placed with a heavy tack coat using a spray paver compared with conventional tack methods.

A 2009 section sponsored by Georgia DOT evaluated the use of alternative aggregate sources for stone-matrix asphalt (SMA), a premium mix used on Georgia's high-volume interstate highways. The SMA test section contained a higher percentage of flat and elongated particles, yet had excellent performance with regard to rutting, cracking and raveling. These results indicate that aggregate sources meeting Superpave specifications perform as well as the higher-cost cubical aggregate currently used for SMA in Georgia.

Perpetual Pavements and Structural Design

Two sections placed in 2003 that were designed to reach terminal serviceability at 10 million ESALs have survived an impressive 30 million ESALs at the test track. Both sections were designed using the 1993 AASHTO Pavement Design Guide, with an asphalt structural coefficient of 0.44 (the Alabama DOT standard at the time). The sections differ with respect to binder grade—one used PG 67-22, whereas the other used SBS-modified PG 76-22. After 30 million ESALs, both sections exhibited minimal rutting and no fatigue cracking. These results indicate that pavements can withstand higher levels of strain

Results indicate that pavements can withstand higher levels of strain than suggested by lab tests, allowing the design of perpetual pavements with thinner cross-sections that are more cost-competitive.

than suggested by lab tests, allowing the design of perpetual pavements with thinner cross-sections that are more cost-competitive.

Recent research at the test track has also shown that the asphalt structural coefficient can be increased from 0.44 to 0.54 for flexible pavement designs using the 1993 AASHTO Pavement Design Guide. The coefficient recalibration was based on structural measurements from test sections with a broad range of asphalt thicknesses and mix types, as well as different bases and subgrades. Increasing the coefficient to 0.54 results in approximately 18 percent thinner asphalt cross-sections. Alabama DOT estimates savings of approximately \$40 million per year since implementing the revised layer coefficient.

MEPDG Predictions vs. Actual Performance

Performance data from the 2003 and 2006 structural sections at the test track were compared with performance predictions using the Mechanistic-Empirical Pavement Design Guide (MEPDG). Using the national calibration coefficients generally over-predicted rutting. However, newly calibrated coefficients

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Former NCAT Associate Director Receives AAPT Honor

Prithvi (Ken) Kandhal, associate director emeritus of NCAT, recently received honorary membership in the Association of Asphalt Paving Technologists (AAPT). This honor comes after 40 years of work in the AAPT and the field of asphalt pavement design and construction.

NCAT Director Emeritus Dr. Ray Brown, who nominated Kandhal for the award, says Kandhal's involvement and leadership in the AAPT and "helped advance AAPT's reputation to the preeminent organization it is today."

Kandhal also contributed a great deal to NCAT during his time as assistant director and, later, associate director. He is one of the key authors of the NCAT textbook *Hot Mix Asphalt Materials, Mix Design, and Construction*, and he was a primary instructor and course designer for the internationally renowned NCAT Professor Training Course.



Prithvi (Ken) Kandhal (right) receives his NCAT Wall of Honor plaque from NCAT Director Randy West in Aug. 2011. Kandhal has made many contributions to both NCAT and the AAPT.

In 1998, he launched *Asphalt Technology News*, NCAT's biannual newsletter and continued to produce the publication until his retirement. Today, the newsletter is one of the center's main outlets for disseminating NCAT research and other relevant news, as well as a forum for highway agencies to share specifications, suggestions and questions related to asphalt pavements.

Kandhal's significant research and outreach contributions during his 13 years at NCAT earned him the title of associate director emeritus upon his retirement. He is also part of the NCAT Wall of Honor, established in 2011 as part of the center's 25th anniversary celebration.

The India native's interest in asphalt pavements began in his home country, where he was introduced to asphalt as a highway agency engineer.

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for the unbound layers produced acceptable rutting predictions. Fatigue cracking predictions were unsuccessful, with poor agreement between measured and predicted performance regardless of the coefficients used. Grouping sections with similar characteristics may result in better fatigue calibration results, an approach that may be helpful in analyzing data for the 2009 sections.

Research at the test track is also contributing to further understanding of laboratory performance tests and modeling predictions. The NCAT lab has conducted extensive testing on the mixes from the test sections, and researchers have carefully analyzed data using both the conventional pavement design approach and mechanistic-based methods. One of the key findings is that some of the tests used to assess cracking performance use unrealistic strain levels that result in different performance rankings compared to observations in the field. This is especially relevant in the characterization of high-RAP content mixes.

The focus of research for the test track's fifth cycle, scheduled to begin this summer, will be exploring ways to help transportation dollars go further. A number of sections from the fourth cycle, including the WMA and 50 percent RAP sections, will likely remain in place for further trafficking as part of the Preservation Group experiment. Pavement preservation treatments (e.g., thin overlays and inlays, microsurfacing, chip seals, and other surface treatments) will be applied when a predetermined level

of distress is reached. Further performance monitoring will allow researchers to determine the life-cycle cost of various pavement preservation alternatives relative to pretreatment condition.

Preservation treatments will also be applied to a local county road that provides access to a quarry and asphalt production facility. The existing pavement condition varies from good to poor. This study will expand the scope of testing on the test track into a "proactive versus reactive" experiment that defines the relationship between life-cycle performance and pretreatment condition for popular preservation alternatives.

Multiple sponsors will also be participating in the Green Group, which will be constructed this summer using high recycled contents—both RAP and recycled asphalt shingles (RAS)—in addition to unconventional materials and alternative design methodologies. The goal will be to assist states with implementation of these green technologies that have the potential to reduce initial construction cost, pavement thickness and environmental impact.

There are many sponsorship options available at the NCAT Pavement Test Track. For more information, go to www.pooledfund.org/Details/Solicitation/1325 or contact Dr. Buzz Powell at 334.844.6857.

Warm-mix and RAP: A Winning Combination

Using warm-mix asphalt (WMA) technologies in recycled asphalt pavement (RAP) mixes is a win-win scenario in every respect. The cost benefits are evident—reduced material costs and less fuel usage. Plus, the enhanced workability of warm-mix can facilitate using increased RAP contents, which translates into even greater cost savings. With sustainable advantages such as conserving natural resources and reducing the emission of greenhouse gases, the WMA/RAP combination also scores high in terms of environmental stewardship.

Beyond economic and environmental benefits, WMA and RAP together create a synergistic mixture. “They go together, like peanut butter and jelly or macaroni and cheese,” says Dr. Randy West, NCAT director. “We should be using them together whenever we can.”

A RAP mix produced at warm-mix temperatures should have ample stiffness to resist rutting, as well as sufficient viscoelastic behavior to resist cracking.

Combining WMA and RAP offers potential improvements in pavement performance compared to using either alone. AASHTO M320 recommends using a softer virgin binder grade for moderate and high (greater than 25 percent) RAP contents. Adding warm-mix is the perfect solution, as lower mixing temperatures result in less binder aging during production and, consequently, a softer binder. A RAP mix produced at warm-mix temperatures should then have ample stiffness to resist rutting, as well as sufficient viscoelastic behavior to resist cracking.

Plant operations are also improved when WMA and RAP are used together. Plant concerns associated with warm-mix include possible incomplete aggregate drying in the drum. Also, when the gas temperature in the baghouse is reduced below the vapor point of water, muddling of the bags can occur. However, these concerns are alleviated with the use of RAP, since aggregate is superheated to compensate for adding RAP at ambient temperatures. Producing RAP mixes at warm-mix temperatures also eliminates blue smoke emissions.



Section N11 at the NCAT Pavement Test Track, shown above, is a warm-mix asphalt section made with 50 percent reclaimed asphalt pavement.

As part of the 2009 Group Experiment at the NCAT Pavement Test Track, two full-depth 50 percent RAP sections were placed—one produced as WMA using the water-injection foaming method and the other as HMA. Each 7-inch structural section included 50 percent fractionated RAP in all three lifts of the asphalt cross-section. Each section used PG 67-22 virgin binder, whereas the control incorporated PG 76-22 binder in the surface and intermediate lifts and all-virgin materials throughout.

After the application of 10 million equivalent single-axle loads (ESALs), the high-RAP WMA section performed as well as the control. No cracking was observed in any of the three sections, and all three exhibited excellent rut resistance. As shown in Table 1, less rutting was seen in the high-RAP WMA section than in the control. Table 1 also shows that changes in texture were very low for the high-RAP and control sections, indicating excellent durability.

Table 1 Final Rut Depths and Texture Changes

| Test Section | Description | Final Wire Line Rut Depth | Mean Texture Depth Change |
|--------------|-------------|---------------------------|---------------------------|
| S9 | Control | 7.1 mm | 0.227 mm |
| N11 | 50% RAP WMA | 3.7 mm | 0.189 mm |
| N10 | 50% RAP HMA | 1.8 mm | 0.178 mm |

¹Texture changes were normalized to Mean Texture Depth at 500,000 ESALs

Two all-virgin WMA sections, one produced using the water-injection foaming process and one with a chemical additive, were also tested in the 2009 Group Experiment at the test track. While the rutting performance of both WMA sections was satisfactory, the rutting performance of the 50 percent RAP WMA section was significantly better.

Deflection testing confirmed that the 50 percent RAP sections (both HMA and WMA) were stiffer than the control. As a result of this increased stiffness, measured strain levels were lower in the high-RAP sections than in the control, particularly at warmer temperatures. Laboratory fatigue testing also indicated that the endurance limit for the RAP-WMA section was significantly higher than the control.

As demonstrated at the NCAT Pavement Test Track, WMA and RAP together create a synergistic mixture that offers improvements in pavement performance and plant operations, as well as significant cost savings and environmental benefits. WMA/RAP is simply a winning combination.

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.

Greg Sholar, Florida DOT

What lift thickness is optimal for SP-4.75 mixtures? What thickness would be considered too thin for good paving practices? Is there a maximum thickness where rutting becomes an issue? What binder grade is being used in this mix type?

Don Watson, NCAT

What practices have agencies successfully used to prevent reflective cracking?

There seems to be growing interest in recycled asphalt shingles (RAS), but are agencies actually seeing an increase in shingle recycling? Are there different handling procedures or mix design guidelines for tear-offs than for manufacturing rejects, since tear-offs are much stiffer?

There is renewed interest in the use of ground tire rubber (GTR). What mesh-size particles have worked best and in what proportions?

What are some of your agency's priority needs in the area of asphalt research?

What challenges do you foresee regarding workforce enlistment and development?

Denis Boisvert, New Hampshire DOT

New Hampshire's experience with warm-mix asphalt (WMA) to date has been favorable. Our specification is of a permissive nature, so most contractors are opting for foaming technologies since they cost less. They are mainly interested in the compaction aid over the fuel savings.

We specified three WMA projects within our maintenance district overlay program, requiring temperatures that were lower than the foaming technologies are capable of to force the contractors to try the new technologies. All projects were completed with a chemical additive, that being the easiest to implement without committing capital investment. Both DOT and contractors were pleased and excited with the results.

Dale Rand, Texas DOT

We recently completed some in-house research on a porous friction course (PFC) mix with shingles to see if we could eliminate the use of additional fibers. When using up to 5 percent RAS, we were not able to get anything to pass the drain-down test unless additional fibers were added. We concluded that the amount of fibers could be reduced but not eliminated when using RAS in PFC mixes.

Former NCAT Associate Director Receives AAPT Honor

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"While working in a dry desert region of India with no stone quarries, I successfully experimented with road construction using dune sand and asphalt," Kandhal adds. "That is when I started to love asphalt."

"Receiving honorary membership in AAPT is a proud moment in my life, especially when it is being accorded by my peers from all continents of the world."

—Ken Kandhal

He later moved to the U.S. and received his master's degree in civil engineering from Iowa State University. After graduation, he spent 18 years at the Pennsylvania Department of Transportation as the chief asphalt engineer. Kandhal arrived at NCAT in 1988.

Some of his notable research accomplishments at both the Pennsylvania DOT and NCAT include work related to the Superpave restricted zone, stripping of asphalt pavements, performance testing

of HMA mixtures, construction guidance for longitudinal joints, tests to determine bulk specific gravity of fine aggregates and aggregate tests related to HMA performance.

Throughout his career, Kandhal has published more than 120 articles in technical journals, as well as trade magazine articles, conference proceedings and more than 20 AAPT technical reports. In 1989, he received the prestigious W. J. Emmons Award for the best paper presented and published by the AAPT. This paper summarized his research on moisture susceptibility of asphalt mixtures.

Kandhal also directly helped increase AAPT membership during his term as AAPT president from 1999-2000. He wrote personal letters to all AAPT conference attendees that year, thanking them for their attendance and encouraging them to join the organization.

In addition, he has been active in several other technical societies and organizations, such as the Transportation Research Board (TRB), the American Society for Testing and Materials (ASTM), and the American Society of Civil Engineers (ASCE).

Kandhal officially received his honorary membership at a formal banquet on April 3 during the AAPT annual meeting in Austin, Texas.

"Receiving honorary membership in AAPT is a proud moment in my life, especially when it is being accorded by my peers from all continents of the world," Kandhal says.

Asphalt Forum Responses

The following responses have been received to questions shared in the Fall 2011 Asphalt Forum.

1. **What is the maximum amount of time that warm-mix asphalt (foam method) has been stored in a silo? At what temperature was it originally placed in the silo? (Chris Jones, Wiregrass Construction)**

Mark Woods, Tennessee DOT

TDOT Specification 407.13, "Mixing," applies to all mixtures and permits storage for 48 and 96 hours depending on the mixture type.

Dale Rand, Texas DOT

Our specifications allow storing the mix in a silo for a maximum of 12 hours.

2. **What types of asphalt mixes/asphalt binders/pavement designs are other states using at interstate weigh station areas that are subject to heavy, slow-moving truck traffic? (Pat Upshaw, Florida DOT)**

Joe Schroer, Missouri DOT

Missouri has had no problems with PG 76-22 and Superpave mix designs at 125 gyrations or stone-matrix asphalt (SMA).

3. **The Nevada DOT is experimenting with warm-mix asphalt (WMA). Statewide, we require 1.5 percent hydrated lime to be applied to the aggregates, which are wetted to approximately SSD moisture and stockpiled for a minimum of 48 hours before use. Do any other states have experience with incomplete drying of aggregates in the drum and related moisture-sensitivity issues? (Darin Tedford, Nevada DOT)**

Denis Boisvert, New Hampshire DOT

New Hampshire does not apply hydrated lime. We have not experienced any moisture-sensitivity issues with WMA to date, after an experimental season in 2010 (14,000 tons or 2 percent) and a full season in 2011 (257,000 tons or 40 percent).

4. **Has any state seen any satisfactory bid numbers, in terms of cost per square yard, for any type of in-place recycling? Has anyone considered alternate contracts such as mill, surface and binder versus hot-in-place (HIP) and surface? Thoughts? (Mark Woods, Tennessee DOT)**

Joe Schroer, Missouri DOT

Missouri does not have many in-place recycling projects in place, but we believe we are getting fair prices. For example, a 4-inch cold in-place (CIR) project will have roughly the

same cost as 2 inches of mill-and-fill HMA. With HIP recycling (HIR), the pricing gets trickier because the savings of the HIR can be made up by the value of the RAP to the HMA contractor. We had a full-depth reclamation (FDR) project with 12 inches of FDR at \$55,000 per mile and a 3-inch overlay at \$83,000 per mile. We bid projects with a multi-lift overlay versus in-place recycling and an overlay with about half going each way.

5. **Are any states having to import aggregate to meet hot-mix asphalt surface friction requirements? What tests are performed to evaluate friction properties of new aggregate sources? (Mike Heitzman, NCAT)**

David Powers, Ohio DOT

Ohio imports limited aggregate in some areas for friction purposes. We currently base aggregate acceptance on actual field performance. However, in the future we will be looking to implement a new mixture lab polish method that has been developed through a series of research studies at the University of Akron. The method is highly correlated to field projects. In this method, 6-inch gyratory mix specimens are polished and then measured with the British Pendulum.

Dale Rand, Texas DOT

In some areas of the state we do have to import aggregate. The primary test we use to classify aggregates is acid insolubility. Aggregates that are highly soluble in acid tend to polish quickly and tend to produce the lowest skid numbers.

Darin Tedford, Nevada DOT

No, our open-graded mixes supply friction course.

Denis Boisvert, New Hampshire DOT

No need in the Granite State.

6. **What states are making plans to implement Asphalt Mixture Performance Tester (AMPT) requirements for HMA mix design? (Mike Heitzman, NCAT)**

Joe Schroer, Missouri DOT

At this time, Missouri does not plan to implement it as part of the mixture design. We are using it to compare performance between similar mixtures for new additives and materials and will use it to check mechanistic-empirical design guide (MEPDG) calibration as our mixtures evolve. At some point in the future, it may figure into a performance specification as we try to move that direction.

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Asphalt Forum Responses

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Darin Tedford, Nevada DOT

We are not planning to implement the AMPT requirements at this time, but maybe after further research.

Mark Woods, Tennessee DOT

Tennessee is still awaiting arrival of our pooled-fund AMPT. Once the machine is here and we have time to work with it, we will determine its place in our program.

Denis Boisvert, New Hampshire DOT

New Hampshire will make use of the AMPT in the mix design approval process. The specifics and timing are not formulated yet, since we need experience with the device.

7. What states are using ground-penetrating radar (GPR) or some other form of non-destructive testing for forensic investigation? (Mike Heitzman, NCAT)

Pat Upshaw, Florida DOT

We currently use air and ground-coupled GPR systems for pavement thickness evaluation and forensics (sinkhole, etc.) evaluations.

Darin Tedford, Nevada DOT

We have only used GPR in research/demonstrations, and we seldom use the falling-weight deflectometer (FWD).

Denis Boisvert, New Hampshire DOT

We have only used GPR for concrete applications, particularly on bridge decks.

Dale Rand, Texas DOT

We use GPR for forensic investigation. The equipment does a good job of detecting moisture and delamination in the pavement structure. We have also used GPR to quantify end-of-load segregation.

8. Is anyone aware of research regarding whether it is best to remove the aggregate with cut faces from cores before testing Gmm, Pb or gradation? (Don Watson, NCAT)

Joe Schroer, Missouri DOT

We did an informal in-house look at this in Missouri 15 years ago and concluded we were altering the gradation and Pb more by removing the cut faces than by using as is. One of our contractors suggested mixing (we use a wire whip) the softened mixture briefly before performing the Rice test to coat the cut faces. We think this has improved the reliability of the Gmm.

2012 NCAT Pavement Test Track Conference • February 28-29, 2012



Top: NCAT Test Track Manager Buzz Powell leads a discussion during the test track tour. Top right: Drs. Randy West and Dave Timm answer audience questions after a conference presentation. Bottom right: Tom and Fiesta McEwen provide live entertainment during the conference dinner on Feb. 28.

Florida

A new specification requirement has been issued related to segregation in dense-graded mixtures. For visually identified segregated areas, cores will be obtained and measured for in-place density. Areas having a density less than 90 percent Gmm will have to be removed and replaced.

Tennessee

The Tennessee DOT recently tightened its production tolerance for 100 percent pay on asphalt content (AC) from 0.4 to 0.3 percent. Warm-mix asphalt is now permitted on any awarded TDOT project. Lastly, the minimum total AC content for 411-D, TDOT's standard 12.5-mm nominal maximum aggregate size (NMA) surface mixture, has been raised from 5.3 to 5.7 percent.

Missouri

In April 2011, the Missouri DOT changed the binder specification, Section 1015, to include an option to produce binder in accordance with AASHTO MP 19. About three years ago, we added a special provision that allowed modification of binders using ground tire rubber (GTR) cross-linked with transpolyoctenamer rubber (TOR) with multiple stress creep recovery (MSCR) as an option to elastic recovery that requires polymer modification. Sections S6 and S7 of the 2009 cycle on the NCAT test track include a comparison of mixtures with SBS and GTR modification. Excellent performance of the GTR-modified mixture after 18 months allowed us to move ahead and add GTR modification to the Missouri Standard Specifications. In doing so, we elected to offer the option of MP 19 for any binder. We allow PG 64-22, and Grade H and Grade V in lieu of PG 70-22 and PG 76-22, respectively. Most polymer-modified binders are now being supplied using the MP 19 protocols due to formulation changes that allow suppliers to manufacture the binders at a lower cost.

Three projects are under contract to use permeability as the measure of density. Two are completed, and the other will be completed in the first half of 2012. The falling head permeameter developed under NCAT Report 99-01 is used as the testing device. One of the basic objectives of density measurements is to produce a long-lasting, somewhat impermeable pavement. Each mixture by its composition has a particular point of reaching impermeability. Designing mixtures with permeability in mind will hopefully reduce the compactive effort required for placement. By measuring permeability, the goals are to reduce permeability in Missouri's pavements and provide an accurate non-destructive test. The projects completed so far also used cores for density measurements and indicate the pay factors for either method are roughly equivalent. It has been found that fresh plumber's putty provides a consistent, satisfactory seal with this method.

New Hampshire

Our quality control/quality assurance (QC/QA) specification has been revised to shift emphasis from thickness to cross slope. It was a small pay-factor change intended to promote

maintenance of our roadway crown, which we observe is diminishing from repeated overlay projects.

We have added a milling tolerance for mill-and-fill projects. The specification forces good milling equipment maintenance. Some contractors do not replace milling teeth uniformly or frequently enough to create an evenly milled surface. This can cause uneven depths between individual passes.

Language has been added to specifically allow warm-mix asphalt (WMA) technologies. This has been done by reference to a Qualified WMA Technologies List, which is essentially the NorthEast Asphalt Users Producers Group (NEAUPG) qualified technologies list. Sections of our specification have been revised to allow lower minimum deliver and mat temperatures when WMA technologies are in use.

Texas

The Texas DOT will be implementing new HMA specifications within the next few months. All the HMA specifications have been rewritten in order to improve the quality of our HMA pavements, reduce cost and be better stewards of the environment. The use of reclaimed asphalt pavement (RAP), reclaimed asphalt shingles (RAS), WMA and "substitute binders" is permitted in most of our new specifications. We have also put more incentive into our specifications for contractors to use the Paver-IR system on paving projects. In addition, we have implemented a system of using security bags to maintain custody of samples when the samples are not within Texas DOT's custody prior to testing. This was done to address the FHWA's concern regarding sample custody.

Stone-matrix asphalt (SMA) mixes will now be required to pass the overlay test (min. 300 cycles) prior to use.

Our new permeable friction course (PFC) specification includes a mix with a smaller nominal aggregate size as one of the options. This fine PFC mix will typically be placed in the 0.75- to 1.0-inch thickness range.

Need RAS Testing?

The NCAT laboratory can meet all your needs for recycled asphalt shingles (RAS) testing:

- Gradation of RAS
- Asphalt Binder Content of RAS
- Performance Grading of RAS Binder
- Deleterious Materials
- Asbestos Testing Using Polarized Light Microscopy

Call Jason Moore at 334.844.7336 for more information.

Visiting Scholars Acquire Research, Unique Experience

When Dr. Flavio Padula graciously describes his experience as an NCAT visiting scholar as “perfect,” he is referring to both his work at NCAT and his family’s quality of life in Auburn.

“Besides all the great opportunities that I was given at NCAT, coming to the U.S. was also a wonderful event for me and my family,” Padula said. “We really enjoyed Auburn and American people.” Padula, who finished his time at NCAT in December 2011, is a civil engineering professor from Brazil.

He is one of about 20 international visiting scholars NCAT has hosted since its inception in 1986. These scholars are typically professors or engineering professionals who receive a grant from their government to learn more about asphalt technologies. They are selected on a case-by-case basis and stay here about six to 12 months.

NCAT has hosted visiting scholars from Africa, Indonesia, Japan, China and Pakistan. The first scholar was African native Badru Kiggundu, who arrived at NCAT in 1989.

Since NCAT does not yet have a formal program for visiting scholars, the center cannot provide them any financial support for living expenses. However, scholars like Padula feel that the opportunity to work at a nationally renowned asphalt research facility is a fair exchange for paying their own way.

Sharing Knowledge

“As a professor, the knowledge gained at NCAT will be disseminated to students and researchers, and will benefit the citizens of Brazil,” Padula says. He is especially excited about passing along what he’s learned about recycling asphalt materials, as he says the Brazilian government does not currently have any guidelines or programs relating to pavement materials recycling.

During his one-year stay, Padula attended five training courses, including the annual Professor Training Course; participated in three research projects; assisted with quality control during a field project; wrote five research papers; and ran several lab tests. Padula says he most enjoyed NCAT’s ideal combination of theory and practice.

“I was able to learn many things in theory, and then see the practice by going to the NCAT test track and construction sites,” he says. “The fact that NCAT has a partnership with state DOTs and the asphalt industry—together with the lab

and track—is the key to the success of NCAT.”

Dr. Gongyun Liao, a visiting scholar from Southeast University in Nanjing, China, said that the test track and its accelerated testing capability was the main draw to NCAT for him. He works in the field of pavement noise.

“The full database of noise data measured at the test track and corresponding pavement surface measurements will pro-



Dr. Flavio Padula from Brazil (left) and Dr. Gongyun Liao from China (right) botrecently completed their time as visiting scholars at NCAT.

vide me a chance to evaluate the relative significance of pavement surface characteristics on noise,” Liao says. “This may be a strong base for future low-noise asphalt pavement design.”

He also says that the “working style and management methods at NCAT” will greatly influence his teaching style and research endeavors when he returns to Southeast University.

Benefits on Both Sides

Dr. Ray Brown, director of NCAT from 1991-2007, said that visiting scholars benefit NCAT as well, explaining that they are “good for our international reputation” and also contribute useful research. NCAT often receives international graduate students as a result of the visiting scholars going home and discussing their experience here.

For Padula, sharing his experience will almost certainly mean talking about his family’s daily activities in Auburn, in addition to discussing his NCAT research. He and his wife especially appreciated that their 5-year-old daughter was able to attend kindergarten for free in the prestigious Auburn City Schools system, and he mentioned how safe and comfortable they felt in Auburn.

Living and studying in the U.S. also meant that both Padula and Liao had to face one of their greatest challenges – improving their English-speaking skills. While he studied English in Brazil, Padula says the accents and colloquialisms here made learning the language much more difficult. But he received help in this area from an unexpected source.

“My daughter is now teaching us English, after being in school here,” Padula says. “This was a great opportunity for us to improve our English skills and learn about the American culture.”

Lab Testing Materials with the Vacuum Oven

Testing asphalt pavement materials such as aggregate, reclaimed asphalt pavement (RAP) and mixture specimens often requires that samples be dried to a constant mass. Most labs accomplish this using convection ovens or fan drying, depending on sample type. The National Center for Asphalt Technology (NCAT) recently completed a study to determine if vacuum ovens are an economically feasible alternative to convection ovens and fan drying in an asphalt pavement lab. The underlying premise of a vacuum oven is that at low pressures, water converts to steam at a much lower temperature, which should enable more efficient drying.

Methodology

The cost of the vacuum oven used in this study was approximately twice that of a standard convection oven of similar size. Circular holes were drilled into the shelves to better facilitate air flow and moisture drainage within the vacuum oven. Per the manufacturer's instructions, the vacuum line was closed once target pressure (26-27 atm below atmospheric pressure) was applied in order to prevent moisture damage to the vacuum pump.

The vacuum oven was evaluated relative to conventional drying methods for three classes of materials: aggregate, recycled asphalt materials and compacted HMA specimens. Six aggregate materials, representing both coarse- and fine-graded stockpiles with a



Vacuum oven .

range of absorption values, were included in the study. Recycled materials included both coarse- and fine-graded RAP, as well as recycled asphalt shingles (RAS). All aggregate and recycled material samples were wetted by adding distilled water (2 percent by weight for coarse materials and 6 percent for fine) and dried at 110°C in both vacuum and convection ovens.

Compacted HMA specimens were also used to evaluate the performance of the vacuum oven. Samples represented three different specimen geometries used for common lab performance tests: dynamic modulus and flow number using the Asphalt Mixture Performance Tester (AMPT), the Hamburg Wheel-Tracking Test, and creep compliance and indirect tensile strength (IDT). All samples were prepared using the same plant-produced 12.5 mm Superpave mix and compacted to 7.0 ± 1.0 percent air voids. All compacted specimens were submerged for four minutes (according to AASHTO T166) and dried to a saturated surface-dry (SSD) condition prior to vacuum oven or fan drying. To minimize sample aging, the vacuum oven temperature was set at 40°C.

For each material, the average drying time was defined as the time of measurement beyond which no more than 0.1 percent sample mass was lost, per AASHTO T255-00. Average drying

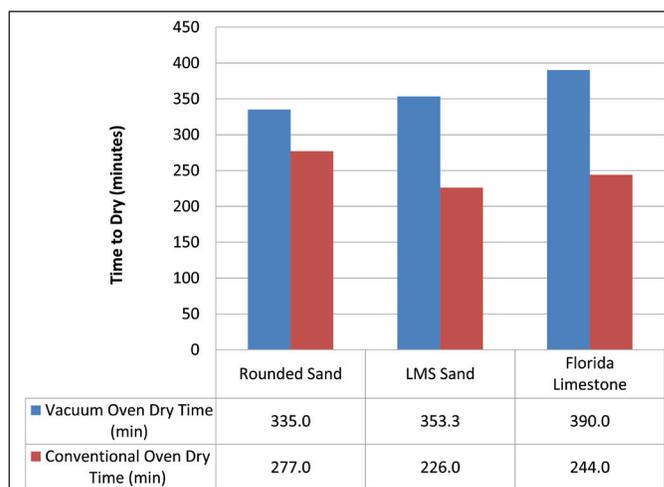


Figure 1 Average drying time for fine aggregate—vacuum oven vs. conventional oven drying.

time for each material was used to determine if the vacuum oven performed better than conventional drying methods. Figure 1 shows an example of the data generated during the experiment.

Results

For the majority of aggregate materials tested, the vacuum oven did not result in faster dry times than the conventional oven. The one exception was low-absorption, coarse, rounded gravel. Theoretically, the vacuum oven should be effective on highly absorptive materials with extensive pore space, but these data did not support this theory.

The vacuum oven provided only a slight drying benefit for the RAS material, which is considered minimally absorptive, and none for the coarse and fine RAP. Again, the only drying benefit with the vacuum oven was observed for low-absorption material. However, RAS is fine-graded, whereas in the aggregate evaluation the drying benefit was observed only with a coarse-graded aggregate. Thus, there appears to be no correlation between gradation and vacuum oven effectiveness.

With the compacted HMA specimens, the vacuum oven showed an improvement in the rate of drying versus fan drying. However, a comparison was not made between the vacuum oven and a conventional oven set to a low temperature for drying compacted HMA samples. It is also unknown whether oven drying would detrimentally age compacted performance specimens.

Additional Testing

During the course of vacuum oven testing, large amounts of moisture evaporated from samples and re-condensed inside the vacuum oven chamber. Since the condensed moisture was unable to escape the sealed chamber, the samples were being dried in a high-moisture environment, which could be a reason why

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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 Don Watson at 334.844.7306.

New Course Focuses on WMA, RAP and RAS

Interest in using warm-mix asphalt (WMA), reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS) has increased in recent years due to rising construction costs and efforts toward sustainability within the asphalt pavement industry. With this interest, however, comes the need for training on best practices for designing asphalt paving mixtures that include WMA, RAP and/or RAS.

NCAT began offering a new training course in January 2012 to address this need. Advanced Mix Design: WMA, RAP and RAS is a three-day course that provides information on testing, performance and cost for each of these processes. Three courses have been held so far, with a total of 38 participants, and one more course is scheduled April 17-19.

"The course is needed at NCAT because these are three new areas (WMA, high RAP and RAS) that have created a lot of excitement in the industry, and we are seeing a rapid increase in their use," says Dr. Ray Brown, director emeritus of NCAT, who helped create the course.

He also said it's important that the industry learns from those involved in previous and existing projects with WMA, RAP and RAS "so that we can minimize any mistakes and ensure better performance on future projects."



NCAT engineer Grant Julian, an instructor in the Advanced Mix Design course, shows participant Chris Counce how to use the warm-mix asphalt foamer during a laboratory demonstration.

The course includes lectures, laboratory demonstrations, hands-on training, and an optional tour of high RAP and WMA sections at the NCAT Pavement Test Track. The lectures focus on topics such as sources of RAP and RAS, mix design procedures, overview of WMA technologies, guidance for field quality control/quality assurance, observed performance of high RAP/RAS and WMA mixes, economic analyses and proposed guide specifications.

In the laboratory, students have the opportunity to handle various WMA technologies, observe performance test equipment operation, and observe mix design and materials testing.

In the first three courses, attendees from state highway agencies have indicated that it is valuable to hear what neighboring states are doing in the three areas.

"There is not a lot of experience with mix design and production of RAS and, hence, attendees feel like the discussion about production procedures and observed problem areas have been very helpful," Brown says.

Material producers, contractors, consultants and highway agency personnel may be interested in this NCAT course. For more information, visit <http://www.ncat.us/education> or call Don Watson at 334.844.7306.

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the vacuum oven was ineffective in drying most aggregate and recycled asphalt materials. Two modified procedures were tested in an effort to address this problem.

First, a large container of desiccant was placed on the vacuum line, allowing the line to remain open during drying. As the escaping moisture was pulled through the vacuum line, it was trapped in the desiccant before it could damage the pump. The high-absorption coarse and fine aggregates were re-tested using this retrofit. While the desiccant was effective in removing moisture, it became saturated quickly and this procedure did not result in an appreciable improvement in drying time.

A second modified procedure involved re-testing the high-ab-

sorption aggregates at ambient temperature, using only vacuum pressure to remove moisture from the materials. This modification was also not effective in reducing drying time.

Conclusions

The vacuum oven did not improve the drying rate for aggregate and recycled asphalt materials, except for those with the lowest absorption values. While the vacuum oven did offer an improvement in drying time for compacted HMA samples compared to fan drying, questions remain regarding this practice. Thus, the performance of the vacuum oven does not warrant its additional cost relative to conventional lab drying equipment.



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