

Asphalt Technology News

IN THIS ISSUE

Auburn University Installs Porous Asphalt on Campus
PAGE 1

National Center for Asphalt Technology Marks 30th Anniversary
PAGE 2

NCAT Announces Four New Researchers
PAGE 5

Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density
PAGE 7

Twins at Birth Differed as They Aged, by Don Watson
PAGE 8

Auburn Students Awarded AAPT Scholarships
PAGE 10

Quantifying Pavement Albedo
PAGE 11

2017 Training Opportunities
PAGE 12

New Generation Accelerated Laboratory Pavement Friction Procedure
PAGE 13

Comparing Pavement Preservation Treatments
PAGE 14

Specification Corner
PAGE 14

Asphalt Forum
PAGE 15

Auburn University Installs Porous Asphalt on Campus



Allen Asphalt Services, Inc out of Smith Station, Ala. paves the porous asphalt path.

A freshly paved walking path at The Edward Via College of Osteopathic Medicine (VCOM) is home to the first porous asphalt on Auburn University's campus. Located in a Natural Resource Management area, the site includes a two-acre pond originally constructed in 1937. The project included repair of the pond's dam and installation of a porous asphalt path and two boardwalks.

The area is currently used by Auburn faculty and students for forestry and biology research, nature observation, and as a field teaching lab. NCAT Assistant Director Mike Heitzman worked with multiple stakeholders to ensure that university researchers and students would be able to utilize the area as a natural resource.

"The characteristics of porous asphalt made it an excellent choice for this project," said Heitzman. "Rainwater will drain down

through the pavement instead of running off to the side or ponding in low lying areas. This is important for the pond area because this type of drainage will help control storm water and filter out contaminants before they wash into the surrounding environment."

Heitzman worked with the Alabama Asphalt Pavement Association to develop a porous mix specification and identify local contractors to work on the project. A challenge for small campus projects is convincing a contractor to produce a very small quantity of porous mix.

Researchers at NCAT will continue to look for additional opportunities on campus to highlight the benefits of porous asphalt as a pavement of choice to control storm water runoff and improve walking surfaces during rain events.

National Center for Asphalt Technology Marks 30th Anniversary

The National Center for Asphalt Technology (NCAT) at Auburn University has built an international reputation for the quality of its research, training, and education. As NCAT prepares to celebrate the 30th anniversary of its inception, we use this milestone to reflect on the center's development and evolution.

Organized by a partnership between the National Asphalt Pavement Association (NAPA) Research and Education Foundation and Auburn University, NCAT has grown significantly since its modest beginnings. The center began operations on Auburn's campus in September 1986 with Freddy L. Roberts, professor of civil engineering, serving as its first director.

"We were originally located in the Harbert Engineering Center and had a staff of six when I arrived as assistant director in 1987," said NCAT Director Emeritus Ray Brown. "As we continued to expand, some of our staff moved to Ramsay Hall. Later, we added additional space near the Auburn airport. We were definitely breaking new ground."



Groundbreaking ceremony at the NCAT Test track, September 29, 1998.

departments of transportation, and the National Cooperative Highway Research Program (NCHRP) have led to research findings that have brought new technologies to practice around the country.

One of NCAT's biggest accomplishments has been training and educating the next generation of leaders in asphalt pavement technologies. Hundreds of individuals worldwide attend NCAT's training classes each year, and Auburn University civil engineering students can gain real-world experience by working in the cooperative education program at NCAT while taking courses in materials and pavements.



Frazier Parker (left) and Ray Brown (right) at the NCAT facility in the Harbert Engineering Center.

NCAT's expansion was just beginning, and dedication ceremonies for a centralized main office facility, state-of-the-art testing laboratories, and 1.7-mile track took place on October 23, 2000. The Test Track has since become NCAT's research centerpiece, uniting real-world pavement construction with live, heavy trafficking for rapid testing and analysis of asphalt pavements. Funded and managed as a cooperative project, the track has led to advancements in pavement design, construction, and maintenance that save sponsoring organizations an estimated \$160 million per year.

NCAT researchers have developed practical and cost-effective solutions to challenges facing the asphalt pavement industry. Numerous studies conducted for the Federal Highway Administration (FHWA), state



Damian Jackson gains practical work experience as an NCAT co-op student.

NCAT was established to provide practical research and development to meet the demands of maintaining America's highway infrastructure. Today, NCAT remains committed to its mission: to provide innovative, relevant and implementable research, technology development, and education that advances safe and economically sustainable asphalt pavements.

“One of the most remarkable things about NCAT is that so much has been achieved in such a short time,” said NCAT Director Randy West. “Our upcoming anniversary is both an occasion for celebration and an opportunity to look forward to the next 30 years of cooperative research

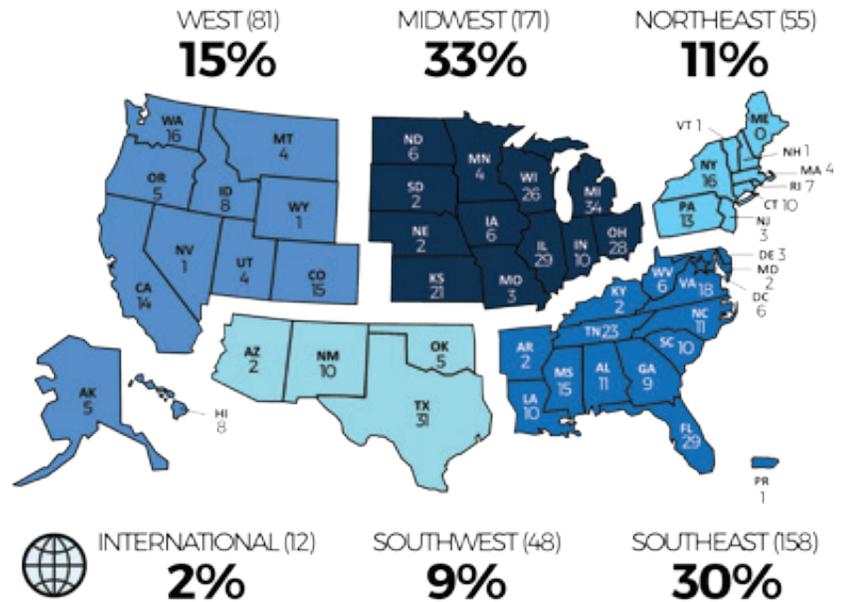
and innovation.” NCAT will celebrate its 30th anniversary during an open house planned for next year.

Here’s a look back at some of the amazing milestones NCAT has achieved throughout the years.

1 Professor Training Course

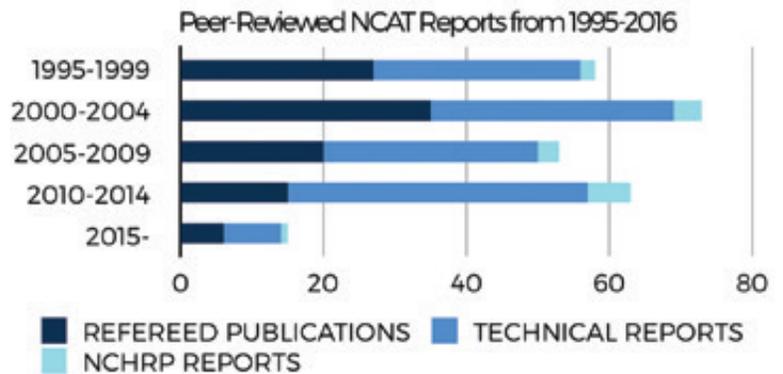
This five-day educational program provides college and university civil engineering faculty clear and up-to-date instructional resources to teach the asphalt portion of an undergraduate civil engineering materials course.

525 Professor Training Course Attendees by Region (1988-2016)



2 Peer-Reviewed Research

Since 1988, our engineers have published over 300 cutting-edge research reports, NCHRP reports, and refereed journal and conference publication articles.



3 NCAT Textbook

NCAT’s Hot Mix Asphalt Materials, Mixture Design and Construction was the industry’s first comprehensive textbook on hot mix asphalt technology. In order to reach a wider audience and provide updated information, a fourth edition is being planned in both print and eBook format.

As of 2016, **THREE EDITONS** of the NCAT textbook have been published, selling over **18,432** copies.

Translations exist in both Chinese and Russian.

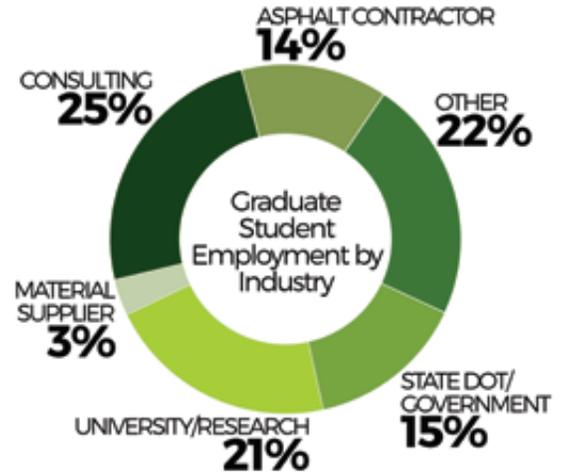
4 Graduate Students

Our graduate students are trained on the most up-to-date technologies and graduate prepared to apply their skills to various industries.

Since **1989**, NCAT has developed **89** graduate students with a combined total of

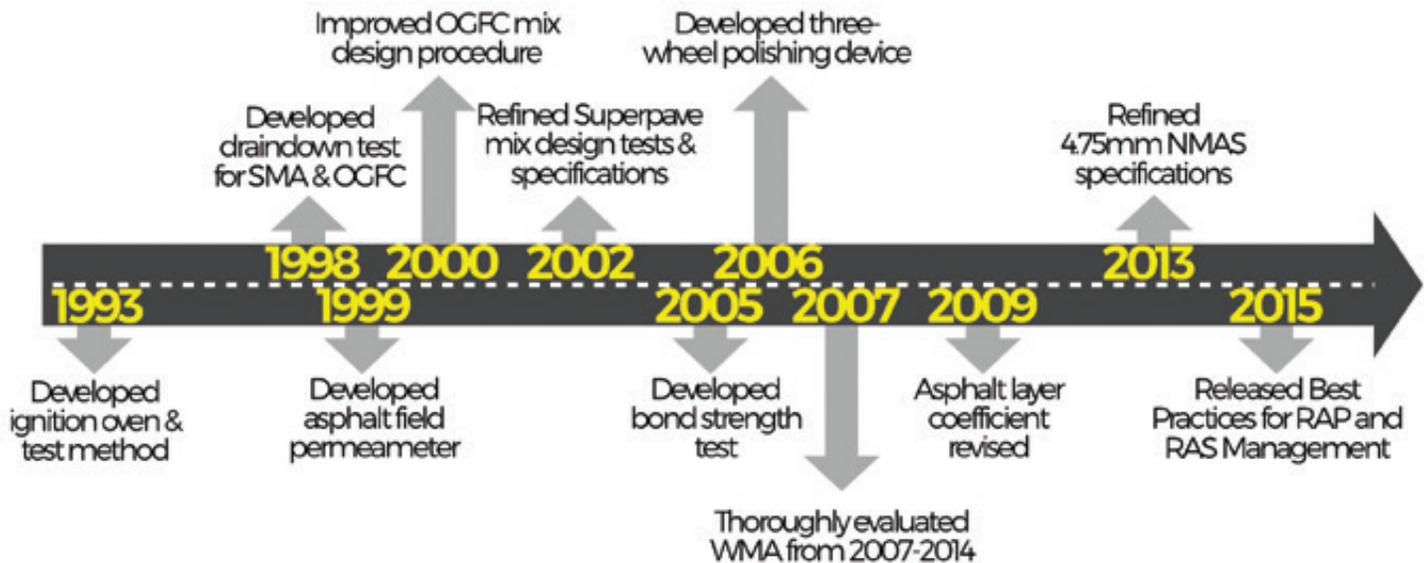
69 Master's

24 Ph.D.'s



5 Advancements in Testing & Design Methods

Findings from our research have led to innovations in equipment design and test methods, bringing new savings and technologies to practice across the country.



6 Economic Impact

NCAT is a significant investment made on behalf of the asphalt pavement industry, creating an economic development impact of over \$125 million to the state of Alabama each year. Our cooperative research, educational programs, and extension efforts carry the benefits of advancements in asphalt technology to the entire nation.



Duplicating this asset would require a capital commitment in excess of

\$40 million

NCAT Announces Four New Researchers



Adriana Vargas comes to Auburn from the University of Costa Rica where she taught civil engineering courses at the undergraduate and graduate level while also working at their national infrastructure lab, LANAMME. Vargas joined NCAT in August as an assistant research professor and will be leading all pavement preservation experiments and teaching a course in pavement management at Auburn University every other year.

She earned her bachelor's degree in civil engineering from the University of Costa Rica and was inspired to work in pavement research after receiving her MBA from the State University at Distance in Costa Rica. "I worked for a company that mostly did pavement management consulting, and I started getting most of my experience that way. It made me realize that there's a lot of work that needs to be done to make sure we keep our pavements in good shape."

Vargas earned her master's degree from Auburn and later worked as a consultant in the San Francisco Bay area. She returned to Auburn to obtain a Ph.D. in civil engineering while working at NCAT as a research assistant. She now looks forward to growing professionally in her new role and expanding her research to different aspects of the asphalt pavement industry.

Although moving away from her family in Costa Rica was challenging, especially with a newborn child, she is excited to be back in Auburn and working for NCAT. She looks forward to attending football games with her husband, Fabricio Leiva.

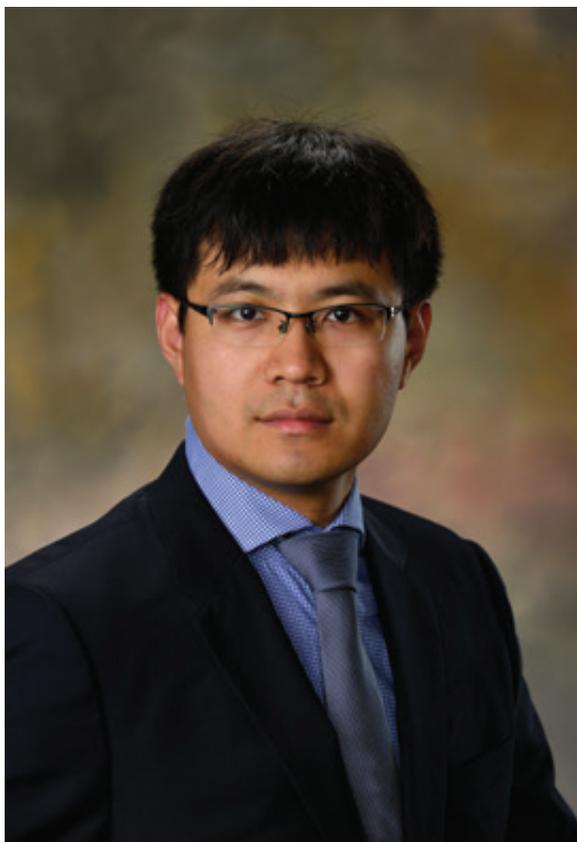
Fabricio Leiva joined the NCAT research team in August as an assistant research professor and will lead research on using recycled materials in asphalt pavements and multi-scale pavement analysis while also teaching civil engineering courses at Auburn University during the summer.

Leiva earned his bachelor's degree in civil engineering from the University of Costa Rica and his master's degree from Auburn while working as a graduate assistant at NCAT. He worked as an engineer in California before returning to Auburn to obtain a Ph.D. in civil engineering. He moved to Costa Rica in 2012 to conduct research on accelerated pavement testing and other asphalt technologies at LANAMME.

Although his interest in pavement technology was fueled by the need to give back to his country, opportunity and the availability of resources is what steered him back to Auburn. "There's a great need to pretty much fix everything that has to do with transportation infrastructure in Costa Rica," said Fabricio. "I was looking for a university that had a big background in materials, especially for pavements. I knew that Auburn University and NCAT could meet my expectations regarding experience and knowledge in pavement materials and accelerated pavement testing."

Fabricio looks forward to cheering on the Auburn Tigers this fall with his wife, Adriana Vargas, and building a new home for their family in Auburn.





Fan Gu joined the NCAT team in September and will be leading research regarding rolling resistance, cold central plant recycling (CCPR) and cold in-place recycling (CIR).

Gu earned his bachelor's and master's degrees in transportation engineering from Southeast University in China before moving to Texas in 2011. After receiving his Ph.D. in civil engineering from Texas A&M University, Gu went on to conduct postdoctoral research with Texas A&M Transportation Institute and was the principal researcher for multiple projects for the Texas Department of Transportation, including an innovation project to develop nondestructive rapid quality assurance/quality control evaluation test methods and supporting technology.

Gu believes in the importance of the transportation infrastructure, which led to his interest in asphalt materials testing and characterization as well as nondestructive evaluation of pavements. "I am excited to collaborate with other researchers on a variety of topics and transfer the findings to the asphalt pavement industry. Joining NCAT is important to me, especially since it's a leading research center in asphalt materials and pavement."

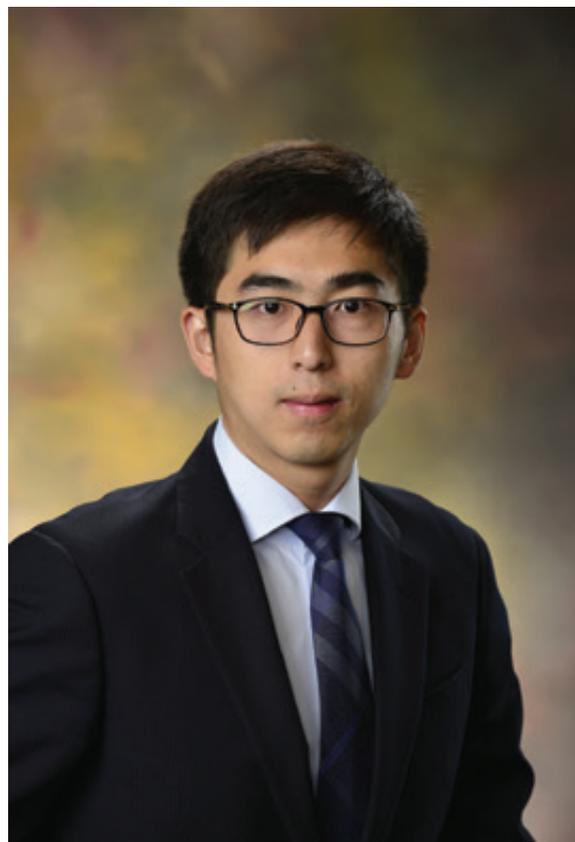
Fan plans on attending Auburn basketball, football, and baseball games with his wife, Di Jin, in his spare time.

Fan Yin joined NCAT in July as a postdoctoral researcher with a strong asphalt pavement background and interests that complement those of other NCAT engineers. Yin will be working on the cracking group research led by NCAT and MnROAD to determine the most appropriate long-term aging protocol that needs to be applied to asphalt mixtures before cracking tests. "This research is a hot topic within the industry," said Yin. "Contractors are trying to use more recycled material to save money—that's why this aging and cracking project is very important. Hopefully we can help the industry use more recycled material and make sure the performance is good as well."

Yin became interested in civil engineering at a young age. "My uncle is a civil engineer. When I used to stay with him as a child he would show me some buildings that he worked on, so I think that's how I got started."

After earning his bachelor's degree in transportation engineering from Southeast University in China, Yin moved to the United States in 2010. He received his master's degree and Ph.D. at Texas A&M University and worked as a graduate research assistant and postdoctoral researcher at the Texas A&M Transportation Institute (TTI). He participated in four National Cooperative Highway Research Program projects on sustainable pavement materials and asphalt material characterization while in this position.

Yin looks forward to beginning his career at NCAT and living in Auburn. During his free time, he enjoys traveling, playing basketball, and hiking with his wife.



Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

A new initiative by the Federal Highway Administration (FHWA) is examining the impact of improved density on the durability of asphalt pavements. The first step was a literature review of prior studies to examine the effect of improved compaction on the life of asphalt pavements. The literature review by NCAT researchers found that a 1% increase in in-place density could increase the service life of a pavement by conservatively 10% (NCAT Report 16-02).

For the second part, the FHWA provided grants for 10 state departments of transportation (DOTs) to construct at least one test section to demonstrate how increased density can be obtained. For each project, a control section was constructed using compaction procedures normally used by the contractor. Test section 1 was constructed using the same mix and compaction equipment but using best practices for compaction with the goal to reach a 1-2 percent higher density. Some DOTs elected to construct a second test section where an altered mix design and/or additional rolling equipment was used to help ensure higher density. The DOTs were required to submit a proposal to the FHWA outlining their approach to improve density in test section 1 and test section 2 (if used). The 10 DOTs selected were Alaska, District of Columbia, Florida, Indiana, Minnesota, Oklahoma, Pennsylvania, Virginia, Washington, and Wisconsin.

Prior to construction on each project, the Asphalt Institute conducted a one-day workshop to present best practices for improving in-place density. The goal of test section 1 was to use these improved rolling techniques to improve compaction but not to add additional equipment. By using these best practices, the process would hopefully provide higher density without significantly increasing construction cost.

Each project also included a mandatory pre-construction meeting for the agency and contractor and a representative of NCAT to ensure that everyone was familiar with the construction plans and the proposed methods for improving density in test section 1 and test section 2 (if used).

During construction, NCAT representatives observed and documented compaction procedures and recorded the locations of test sections, rolling procedures in each test section, mix type and laboratory quality assurance data, in-place density, and other information important to the project. After project completion, the NCAT representative prepared a short report of their observations.



A Material Transfer Vehicle Provides Asphalt Mix to the Paver on I-75 near Lake City, Florida.



Vibratory Rollers Immediately Compact the Hot Mix Behind the Paver on I-75 near Lake City, Florida.

All projects were scheduled for completion in the 2016 construction season. All of the information collected during construction is being compiled into a report documenting quality assurance data and observations. This information will be useful for others who want to improve density and those who may monitor the condition of these sections as they age.

Twins at Birth Differed as They Aged, by Don Watson

Three years ago I gained the honor of becoming a grandfather to twins. Although they were not identical (one is a boy and the other is a girl), it was impossible to look at their faces and tell them apart when they were born. The pink and blue blankets they were wrapped in were an invaluable tool to distinguish which one I was holding. Today, their facial features are quite different and one can easily tell them apart.

During a recent NCAT research study, a similar story developed concerning two asphalt mixes. The two porous friction course (PFC) asphalt surfaces were originally identical as far as one could tell. Both mixes used approved granite aggregate sources which met the same materials specifications, were mixed with polymer modified asphalt binder meeting the same performance grade, were designed using the same mix design procedure, and had the same optimum asphalt binder content. For practical purposes, the mixes were identical.

Just as with my grandchildren, the differences became more pronounced as the mixes aged. One mix was placed on an interstate project with 200,000 average annual daily traffic (AADT) and lasted for more than 18 years before needing to be replaced. The other mix was placed on an interstate project with 50,000 AADT but began raveling and had to be replaced in less than eight years. This causes one to wonder how performance could be so different when both mixes met the same specification criteria.

The mix design procedure used to determine optimum asphalt content for the two mixes relied on what is referred to as the “pie-plate” test where batched aggregate samples are blended with asphalt binder in 0.5% increments. The mix is placed in a clear pie plate (taking care not to slide the mix over the plate surface) and returned to a fan-forced oven for a specified length of time at mix production temperatures. Afterward, the samples are removed from the oven and allowed to cool. The plates are then inverted and the amount of drain-down is observed (Figure 1). It

is desirable to have a slight puddle of binder where the binder film coating the aggregate particle contacts the plate surface. This drain-down is believed to ensure that the particles will bond to the existing surface during construction. However, the drain-down method for selecting optimum asphalt content is no longer practical for some agencies because modified asphalt binders and fiber stabilizers are now added to the mixtures to avoid binder drain-down.

Two nationally recognized test procedures, ASTM D7064-08 and AASHTO PP 77-14, have been developed for practitioners designing PFC mixtures, but neither of the procedures is widely used. The ASTM method recommends optimum asphalt content be based on meeting a minimum air void criteria and maximum drain-down value. Moisture susceptibility testing must result in a minimum tensile strength ratio (TSR) of 80%. The Cantabro test, a test used to evaluate durability, and a permeability test are optional. Obviously, a lower asphalt content will result in higher air voids and less potential for drain-down. The weakness in this procedure is that it ensures that the lowest asphalt content within agency specification ranges will be selected as optimum so long as the TSR requirements are met.

The AASHTO mix design procedure, TP 77-14, is similar to the ASTM procedure but it incorporates the Cantabro test, AASHTO TP 108, into the design procedure. Some agencies have reported satisfactory PFC performance with Cantabro stone loss values up to 20%. TP 77 also establishes a desirable air void range of 18-22%, which will limit how low the asphalt content may be.

Both ASTM and AASHTO procedures require moisture sensitivity testing (AASHTO T283-modified), but AASHTO TP77 requires only one freeze-thaw cycle while the ASTM procedure requires five cycles. ASTM also requires a minimum TSR value of 80% while AASHTO requires 70%.

A quick look at the Cantabro results for the two mixes discussed shows rather dramatic differences. The differences are significant enough that placement of the poor performing mix might have been avoided if the Cantabro test had been conducted during the mix design procedures. TP 108 requires that a compacted PFC sample be placed in a Los Angeles (L.A.) abrasion drum without the normal steel spheres. The drum is then rotated for 300 revolutions at 30-33 rev/min according to

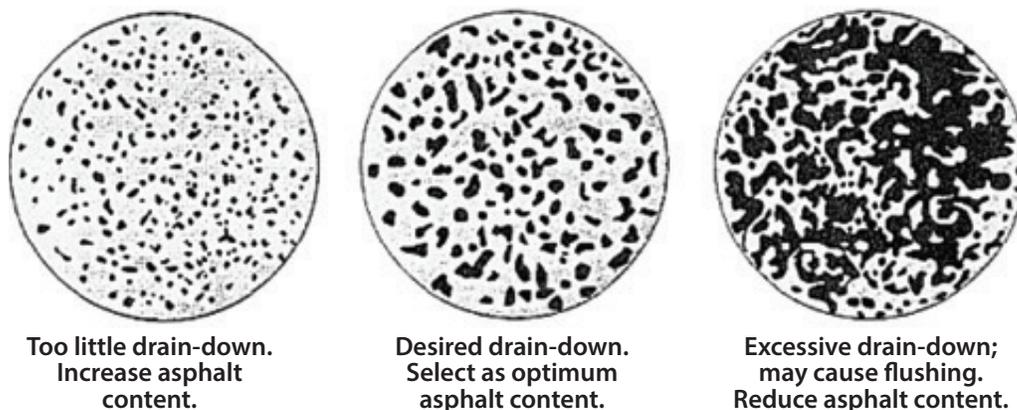


Figure 1: Drain-Down Method for Determining Optimum Asphalt Content

AASHTO T 96. The average loss reported is based on the results of three replicates at each asphalt content.

Cantabro stone loss was determined at three asphalt contents for the two mixes compared to the maximum recommended loss of 20%. The poor-performing mix failed badly with 37.9% stone loss and had nearly twice the amount of loss as the good-performing mix at the 6% optimum asphalt content. Increasing asphalt content is typically recommended to reduce Cantabro loss. In this case, however, it would require almost 8% asphalt by weight of total mix in order to meet the 20% maximum stone loss requirement. Increasing typical asphalt contents by 2% would significantly increase the cost of the mix to the point agencies may no longer consider it feasible to place PFC mixtures.

NCAT evaluated the effect of increasing the percent passing the No. 200 sieve (P_{-200}) on Cantabro results. Additional mineral filler (baghouse dust) was added to a blend that originally contained about 2% total P_{-200} . The additional filler was included at the rates of 2% and 4% by weight of aggregate. Figure 2 shows a significant improvement for the poor-performing mix as the P_{-200} content was increased. The amount of stone loss was reduced by one-half just by the addition of 2% baghouse dust without increasing asphalt binder content. In fact, increasing the total P_{-200} by 2% improved both mixes as well as (or better than) 1.0% additional binder.

A concern with adding P_{-200} in PFC mixes is that it will fill air voids and reduce the permeability of the mix. Such was the case with the good-performing mix. At 6.0% asphalt binder content, the mix only had 15.6% air voids before adding more dust. Adding just 2% more dust reduced the air voids below the minimum acceptable level of 15% and permeability was reduced by one-half. Table 1, however, shows that the poor performing mix still had acceptable air void levels and had permeability values well over the suggested minimum of 100 meters/day even with 5.6% total P_{-200} . This means that performance of some PFC mixes can be improved considerably by increasing the total P_{-200} allowed in the mixture without increasing binder content and without reducing permeability to unacceptable levels. One benefit of this research is that mix designers may be able to use less costly standard quarry materials rather than washed coarse and fine aggregates.

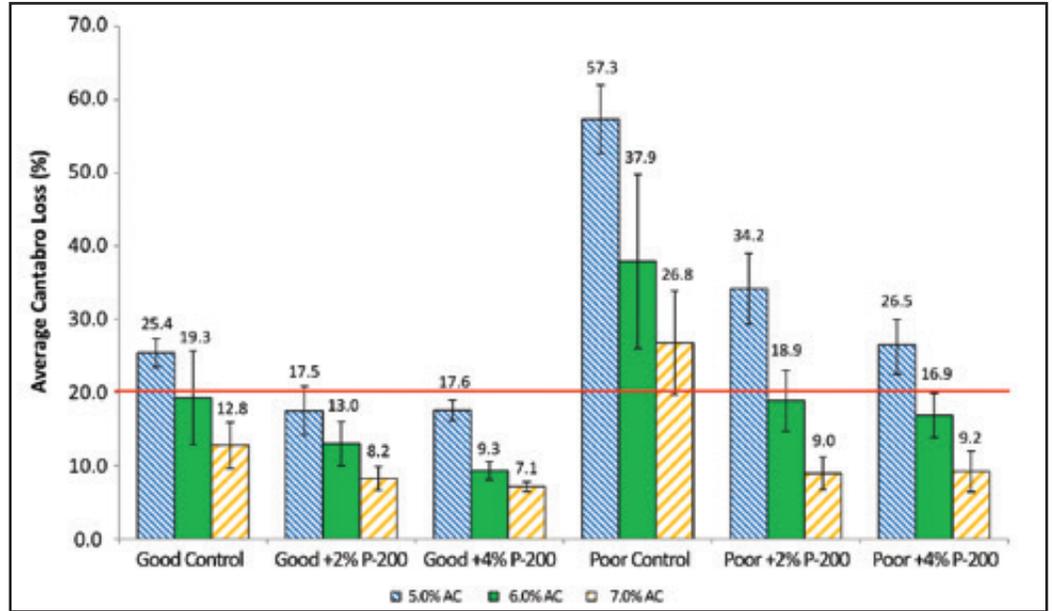


Figure 2: Cantabro Results Based on Mix Design Verification

Table 1: Effect of P_{-200} on Air Voids (V_a) and Permeability

Mix I.D.	Total P_{-200}	V_a	Permeability k , m/day
Good Control	2.0	15.6	80
Good +2% P_{-200}	3.9	13.4	43
Good +4% P_{-200}	6.0	13.2	38
Poor Control	1.7	22.2	209
Poor +2% P_{-200}	3.7	20.6	222
Poor +4% P_{-200}	5.6	19.2	196

Tensile strength tests were conducted to further evaluate the cohesiveness of PFC with increased P_{-200} . AASHTO T 283 was modified as mentioned in AASHTO TP 77 for determining moisture susceptibility. Modifications to the test procedure include:

- Compact to 50 gyrations instead of to a specific air void level,
- Vacuum saturate for 10 minutes, and
- Keep samples submerged during the freeze-thaw cycle.

Figure 3 shows that tensile strengths of both the good and poor mixes improved with the addition of P_{-200} . For the good-performing mix, tensile strength increased for 2% additional P_{-200} but 4% additional P_{-200} did not provide any benefit. Tensile strength increased by 26% for unconditioned specimens and 48% for conditioned specimens when compared to the mixes without added P_{-200} . TSR values ranged from 78% to 86%. The minimum TSR required in TP 77 is 70%.

The poor mix without added P_{-200} had a TSR value of

81%, but the strength was very low with only 45 psi for the unconditioned specimens and 37 psi for the conditioned set. The unconditioned strengths increased for the poor-performing mix with each of the additional P_{-200} levels. The unconditioned strength with 4% added P_{-200} was 71% higher than the control mix without added P_{-200} . The conditioned strength changed very little with 2% added P_{-200} but increased by 46% with 4% additional P_{-200} . These results show that the cohesive strength of a PFC mix can be increased considerably by increasing the P_{-200} content, and in some cases this can be done while still maintaining acceptable levels of permeability.

There are some important observations and conclusions that can be drawn from this research. First, just because two mixes meet the same specification criteria for materials does not ensure that both mixes will have equal field performance. All mix design procedures, including PFC, should include performance tests and criteria. The performance tests should address the main types of distress encountered by the pavement. This important step will help avoid the use of mixtures with inherent weaknesses that otherwise may not manifest until placed in service. Secondly, contrary to previous philosophies regarding minimizing P_{-200} in PFC mixtures, some

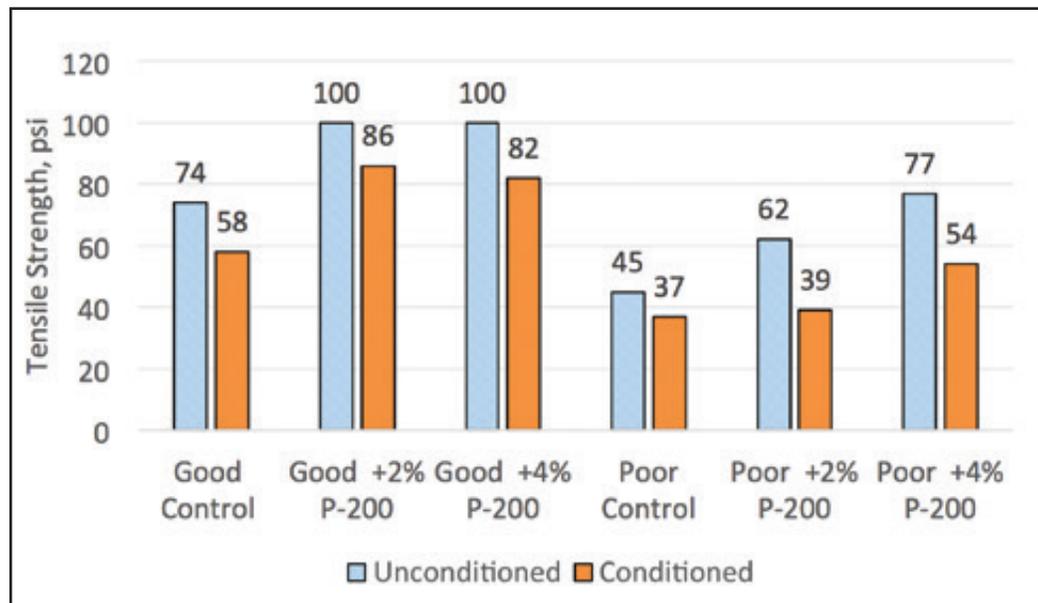


Figure 3: Tensile Strength Results of Unconditioned and Conditioned Specimens

additional P_{-200} may help improve cohesive strengths of the mixtures and reduce the potential for raveling. Less expensive aggregate may be used in PFC production because washed coarse and fine aggregate is not needed.

In summary, it is possible to improve the durability of PFC pavements by implementing performance tests such as the Cantabro wear test, the modified moisture susceptibility test, and the permeability test as part of the laboratory mix design procedure. Agencies should also consider allowing higher P_{-200} contents to improve mixture cohesion and tensile strength. In doing so, those twin pavements may continue their similarities throughout many years of performance.

Auburn Students Awarded AAPT Scholarships

Auburn University Civil Engineering graduate students Nathan Moore and Kenneth Tutu have been selected to receive scholarships from the Association of Asphalt Paving Technologists (AAPT). Their annual scholarships are aimed to support students pursuing careers in asphalt pavement technology. Selected from an international pool of candidates, Nathan and Kenneth were this year's only AAPT scholarship recipients. Nathan is pursuing an MS degree while Kenneth is a doctoral candidate. Both students are conducting asphalt pavement research at the NCAT Test Track under the direction of David Timm. Their achievement will be officially recognized at the annual AAPT meeting in March 2017.



Graduate Students Nathan Moore (left) and Kenneth Tutu (right) at the NCAT Test Track.

Quantifying Pavement Albedo

Albedo is a measure of how much solar energy is reflected by a material. Pavements with lower albedo tend to absorb more solar energy, resulting in higher pavement temperatures, whereas pavements with higher albedo typically absorb less solar energy, resulting in cooler pavement temperatures. Temperature-related asphalt pavement distresses such as rutting and fatigue are influenced by pavement albedo. To account for this, mechanistic-empirical design performance prediction models include thermal property inputs such as solar absorption. On a broader scale, pavement temperature plays some role in the urban heat island effect.

Albedo is computed as the ratio of solar energy reflected to solar energy received, and therefore is a unitless value. A material with high albedo (a value closer to 1) reflects more solar energy, whereas a material with low albedo (a value closer to 0) absorbs more solar energy. Typically, a lighter color is more reflective than a darker color. Thus, newly constructed concrete pavements have a higher albedo than newly constructed asphalt pavements. However, as pavements age, albedo changes—concrete pavements usually darken over time, decreasing their albedo, while asphalt pavements typically become lighter, increasing their albedo. Pavement albedo is also affected by material properties, including the type of aggregate used.

This FHWA-sponsored study focused on quantifying pavement albedo for both concrete and asphalt surfaces. The research team—the National Concrete Pavement Technology Center at Iowa State University and NCAT—took field measurements in seven states and used the results to develop predictive albedo models relative to pavement type, surface age, and aggregate color.

Testing locations were geographically distributed and selected to include pavement containing dark and light aggregates. Sites included Cape Girardeau, Missouri; Waterloo, Iowa; South Bend, Indiana; Sioux Falls, South Dakota; Greenville, South Carolina; Austin, Texas; and several locations in Mississippi. Three of these sites are located in cold-weather climates where pavements are subjected to winter maintenance activities, which could influence pavement albedo. At each site, ten locations were selected for testing. These locations encompassed both asphalt and concrete surfaces varying in age from new construction to 20+ years.

Albedo testing followed ASTM E1918-06, which requires taking measurements during the summer months between 9 a.m. and 3 p.m. to meet solar energy input criteria. Cloud cover was avoided as much as possible during testing. Measurements were taken using an albedometer, which includes an upward-facing pyranometer that measures incoming solar energy and a downward-facing

pyranometer that measures solar energy reflected by the pavement. As shown in Figure 1, the downward-facing pyranometer is positioned at 0.5 m above the surface and creates a scanned area comparable to the width of a standard traffic lane.



Figure 1: Leveling an Albedometer for Field Testing

Aside from pavement type and surface age, the variables expected to have the highest impact on pavement albedo are surface color, coarse aggregate color, and surface texture. These data were also collected at each location. The pavement surface color in the center of the lane and in the wheel path was visually matched with a grayscale chart. Each shade on the grayscale chart was correlated with a grayscale value from 25-255, with higher numbers representing lighter shades. For the sites evaluated in the study, an analysis of the surface color data indicated there were no consistent or practical differences between center of the lane and wheel path measurements. Cores were also cut at each location, allowing measurement of the dominant coarse aggregate color in the same manner. Pavement surface texture, expressed as mean texture depth (MTD), was measured at the center of the lane and in the wheel path of each location using the sand patch procedure. For surface texture values greater than 0.70 mm MTD, differences exist between the center of the lane and wheel path measurements. However, analysis showed that the differences should not bias the albedo model.

Best-fit regression curves for field-measured albedo at each site are shown in Figure 2. The plots show that asphalt pavement albedo increases over time, while concrete pavement albedo decreases over time. After 10-15 years, the asphalt and concrete albedo values begin to converge. While the albedo curves within each pavement type have a similar shape, the curve for each site is unique, and the long-term trend values are different for each site.

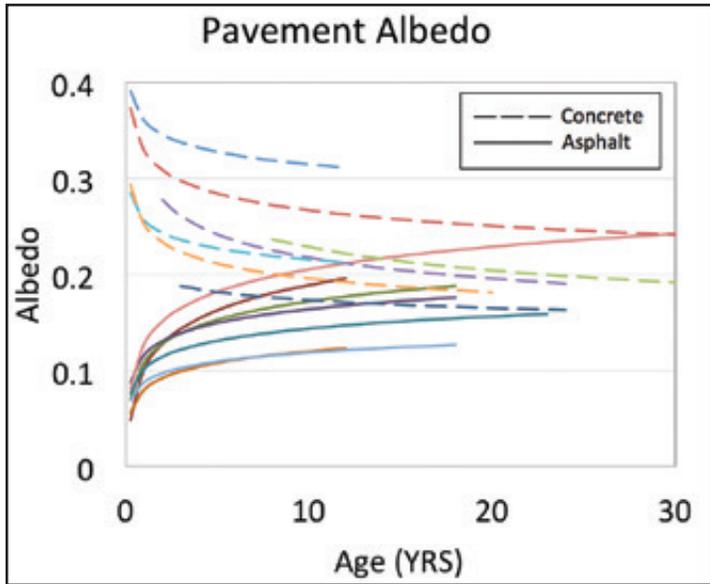


Figure 2: Field-Measured Asphalt and Concrete Surface Albedo Change with Time

For the asphalt albedo model, the best fit regressions were logarithmic equations in the general form

$$Y = a \times \ln(X) + b$$

where Y is the albedo value, X is the pavement surface age in years, and a and b are regression coefficients. Coarse aggregate color most influenced the coefficients. A predictive model for the albedo of asphalt pavements was developed, including only surface age and coarse aggregate color as inputs.

The concrete albedo model was developed in a similar manner. The best fit regressions for the concrete albedo data were power equations in the general form

$$Y = a \times X^b$$

where Y is the albedo value, X is the pavement surface age in years, and a and b are regression coefficients. Analysis showed that surface texture was a predominant factor influencing albedo for concrete pavements. However, surface texture depends on individual job specifications and construction quality, so it is a less consistent variable than coarse aggregate color which also showed a strong effect on albedo. However, a reliable model could not be established to predict albedo using pavement surface age, coarse aggregate color, and surface texture. Further research is needed to determine additional pavement characteristics that contribute to concrete pavement albedo.

2017 Training Opportunities

Our training courses are designed for the asphalt pavement industry, and we can customize workshops designed to meet your specific training needs. We also offer a Professor Training Course for university faculty. CEU's and Professional Development Hours are available.

Training is conducted at NCAT's state-of-the-art research facility in Auburn, Alabama. Course details and registration can be found online at www.ncat.us/education/training.

Advanced Mix Design

January 24-26, 2017

SMA/OGFC Mix Design and Construction

February 14-16, 2017

Asphalt Technology Course

February 20-24, 2017

Balanced Mix Design

March 14-16, 2017



Superpave Mix Design

March 27-31, 2017

Binder Technician Training & Certification Course

April 17-20, 2017

DID YOU KNOW?

Our AASHTO-accredited lab can provide independent performance testing for a nominal fee.

- Hamburg Wheel-Track Testing
- Asphalt Pavement Analyzer (APA)
- Flow Number
- Dynamic Modulus (E^*)
- Resilient Modulus (M_r)
- Overlay Test
- Illinois Flexibility Index Test (I-FIT)
- Semi Circular Bend Test (SCB)
- Indirect Tensile Creep Compliance
- Disk-Shaped Compact Tension Test (DCT)
- S-VECD Fatigue Test
- Bending Beam Fatigue
- Bond Strength
- Tensile Strength Ratio (TSR)

Contact NCAT Lab Manager Jason Moore at moore02@auburn.edu or 334-844-7336.

New Generation Accelerated Laboratory Pavement Friction Procedure

Highway agencies desire to provide a certain level of pavement friction based on the traffic level and speed limit of the route. Material specifications typically identify suitable friction aggregates based on historical field performance and one or more aggregate attributes, such as mineralogy or British pendulum number. Often, the historical field performance relates to coarse graded surface mixtures placed ten or more years prior. As agencies move to smaller NMA surface mixtures, are the friction aggregate specifications still valid? If the criteria are specified for coarse aggregate but the amount of coarse aggregate in the mixture is substantially reduced, will the pavement friction performance remain the same?

As asphalt surface mixtures change, agencies are faced with a decision to apply very conservative friction aggregate criteria or perform a friction study to monitor friction performance under traffic for a range of aggregates and mixes. The conservative approach is quick but could be costly if friction aggregate is an expensive imported material. A full-scale friction study creates optimal criteria but is costly, takes years, and may place the driving public at risk. As an alternative to full scale field testing, NCAT has developed an accelerated laboratory procedure to measure friction performance on asphalt mixtures rather than the traditional approach to testing aggregates. The full procedure can be completed in less than two weeks.

In this procedure, NCAT prepares 20-inch by 20-inch asphalt slabs 2 inches thick using a rolling kneading compactor. After a slab is prepared, it is placed on a rigid steel pallet to prevent deformation. The initial friction properties of the slab surface are measured using ASTM E1911 "Standard Test Method for Measuring Paved Surface Frictional Properties Using the Dynamic Friction Tester (DFT)." The surface of the slab is then polished at an accelerated rate using the NCAT Three Wheel Polishing Device (TWPD). The

TWPD polishes the surface with three pneumatic tires and operates at 60 revolutions per minute with a constant flow of water to wash away fines. A template is placed around the slab as a guide for the DFT so the friction measurements will be taken in the same wheel path. DFT measurements are taken at intervals up to 140,000 cycles to determine the surface's friction performance curve and terminal frictional value.



Figure 2: NCAT Three Wheel Polishing Device

NCAT has completed several national and state studies with this procedure. A typical study includes preparing a surface with a known friction field performance (the agency's standard friction surface) and preparing one or more test surface mixtures with varying aggregate types and proportions. The study determines if the test mixture surface will perform equal to the standard. This is the next-generation procedure to develop good performing asphalt surface mixtures. The laboratory results are based on mixture performance (not coarse aggregate) and the dynamic friction tester (advanced small-scale test).



Figure 1: Preparing 20x20 Slabs with a Linear Kneading Compactor



Figure 3: Measuring Slab Surface with a Dynamic Friction Tester

Comparing Pavement Preservation Treatments

Highway agency interest in pavement preservation has grown significantly over the last five to ten years. The theme “Keeping Good Pavements Good” is critical to maintaining pavement assets. There are a number of pavement preservation treatments (PPTs) available to agencies. Engineers and program administrators typically use a cost-effectiveness measure to compare PPT alternatives similar to using life-cycle cost analysis for determining the best pavement rehabilitation or reconstruction alternative. The depth of the cost-effective analysis will play a role in selecting the most appropriate PPT alternative.

Many reports on PPT define cost-effectiveness as the cost of the PPT application (construction) divided by the lane-miles covered to establish a unit cost per lane-mile, which is further divided by the anticipated life of the treatment to obtain a unit cost per lane-mile per year of service. This is a reasonable method to begin a comparison between PPTs, but requires a set of definitions to consistently compare alternatives. The defined cost must include the same construction items, such as material cost, pavement preparation, placement cost, and traffic control. More difficult to define is the anticipated service life. Each PPT has a unique service performance curve that the agency must determine. The agency should establish a threshold service condition that can be reasonably measured. It can be as simple as a measure of roughness (ride) or more complicated as a pavement condition index that combines multiple measures such as ride + cracking + rutting. The anticipated PPT service life is quantified as the time to reach that defined level of service.

In Figure 1, two PPTs are shown to reach the target service condition in the same length of time, so the difference in cost will determine which PPT is the most cost-effective. However, the two PPTs do not provide the same level of pavement service over the anticipated service time. The level of service during the service time is an appropriate second consideration in developing a procedure to compare alternatives. As shown in Figure 1, PPT-A (red) provides GOOD performance for 75% of the service time, while PPT-B (green) only provides GOOD service for 50% of the time. Quantifying the value of the level of service is not a current common practice but needs to be further explored. If a project requires a PPT with a smooth ride and low noise, then the cost-effective value of a given PPT should account for that desired level of service. If another project requires high friction properties, then each PPT alternative should include the friction performance as part of the cost-effectiveness.

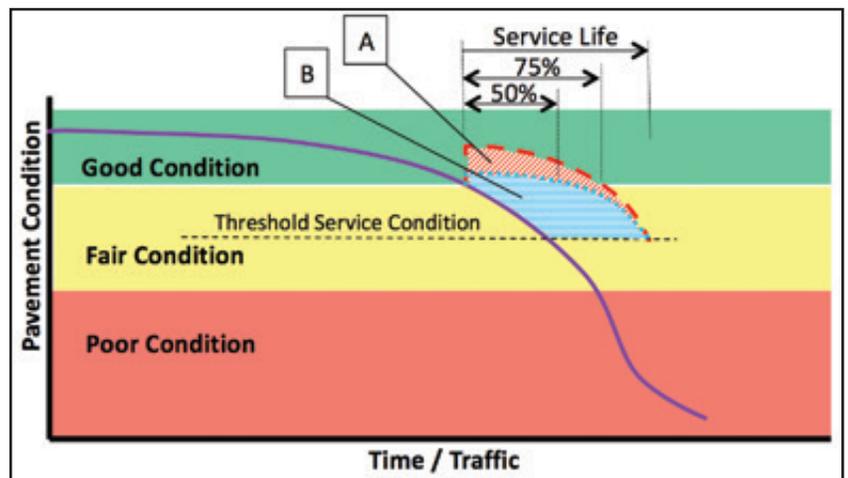


Figure 1: Comparing Service Life and Level of Service

Specification Corner

Colorado DOT

We have revised our microsurfacing, slurry seal, chip seal, double chip seal, and cape seal specifications to get them more in line with the national ISSA standards.

Florida DOT

Effective January 2017, PG 76-22 (ARB) and PG 76-22 (PMA) will be considered equivalent, and it will be the contractor's choice to decide which binder to use for projects requiring a PG 76-22. Currently, PG 76-22 (PMA) is used for higher traffic level roadways and PG 76-22 (ARB) is used in lower traffic roadways.

Montana DOT

We have implemented a binder replacement specification instead of controlling RAP or RAS as a % of the mix. Our longitudinal joint specification now requires 91% theoretical maximum density (TMD), and we are allowing contractors to submit Hamburg mix design results in lieu of verification.

Tennessee DOT

As of June 2016, distributors must be able to spray at a minimum controlled rate of 0.05 gal/SF (previously 0.2). As of July 2016, J_r (diff) is waived for PG 82-22 and maximum LA Abrasion value has been raised to 40% for OGFC, primarily to allow the use of granite. As of November 2016, an anti-strip agent will be required in all mixes.

Asphalt Forum

NCAT invites your comments and questions, which may be submitted to Christine Hall at christine@auburn.edu. Questions and responses are published with editing for consistency and space limitations.

Eric Biehl, Ohio DOT

For states that require fractionated RAP, at what RAP percentage do you start to require fractionation, and how are the sizes handled? Have you noticed if this has helped eliminate segregation due to too much RAP?

Cliff Selkinghaus, South Carolina DOT

How many states are using WMA as a tool to assist with placement issues that sometimes occur when paving over pavements that have previously been crack sealed? Do you have a minimum curing time in your specifications for paving over crack sealants? Do you use any other sealants besides ASTM D6690 Type 1 material to seal cracks?

Matthew Chandler, Tennessee DOT

What experience do other states have with adhesives for longitudinal joints during construction? If successful, was the application pre-applied, post-applied, or both?

Have any states successfully implemented a post-milling sweeping/vacuum performance specification?

Have any states had trouble with their AC suppliers meeting the % recovery curve for a single grade bumped binder (i.e. H grades under MSCR)?

Asphalt Forum Responses

The following responses have been received to questions shared in the previous issue.

Are the G_{sb} values used in mix designs in your state determined by the highway department or by the contractor (or mix design lab)? How often are the G_{sb} values tested? -Randy West, NCAT

Michael Stanford, Colorado DOT

G_{sb} values used in mix designs are determined by the contractor and verified by the highway department.

Eric Biehl, Ohio DOT

Ohio DOT performs the testing, which is typically done annually for all sources. If something happens and we can't make it to a source, then we use the quarry's results if their lab is AMRL accredited.

Greg Sholar, Florida DOT

G_{sb} values are determined at the aggregate mines and published on an FDOT website. These values are used by contractors for mix design purposes. The frequency of testing G_{sb} values at the mine varies depending on the running target and standard deviation values, but a rule of thumb is once every two weeks. The DOT's district offices also randomly obtain samples for verification of G_{sb} values.

Mark Zitzka, Montana DOT

G_{sb} is calculated by the contractor's consultant when a mix design is proposed and again by the DOT when the mix design is verified and approved.

Cliff Selkinghaus, South Carolina DOT

SCDOT uses the G_{sb} from our Qualified Products List No. 1 for coarse aggregates. The values are used for information only to track and estimate the binder film thickness on mix designs. These tests are conducted internally at a minimum of once per year by the SCDOT.

Matthew Chandler, Tennessee DOT

TDOT uses G_{se} in the the mix design instead of G_{sb} . Contractors submit this information on their JMF for verification by the TDOT Regional Materials Lab for each design.



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NCAT welcomed visitors from Vietnam Infrastructure Development and Finance Investment Joint Stock Company and BMT Construction Investment Joint Stock Company this summer. The group came to NCAT to learn more about recycled asphalt pavement and the trends of its use in the U.S. and other countries.