


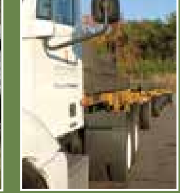

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Asphalt Technology News

IN THIS ISSUE

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Evaluation of Rejuvenating Fog Seals

Delta Mist™ rejuvenator is applied to Section S3 of the NCAT Test Track.

A rejuvenating fog seal is a type of pavement preservation treatment applied to an existing asphalt pavement surface to preserve its functional and structural integrity and delay a more costly rehabilitation treatment in the near future.

A fog seal consists of a slow setting asphalt emulsion (e.g., SS-1, SS-1h, CSS-1 and CSS-1h) diluted with one to four equal parts of water and applied at rates between 0.06 - 0.13 gal/yd^2 on an existing pavement surface without a cover aggregate. It is intended to penetrate into the surface pores of the pavement to seal very small cracks and surface voids as well as coat surface aggregate particles. Pavement surfaces with high void contents are more susceptible to oxidative aging due to greater exposure of the binder to air and higher temperatures. The asphalt binder becomes stiffer, and consequently, more brittle through oxidation, leading to deterioration.

Rejuvenators can be added to fog seals to treat raveled and aged pavements by improving penetration into the pavement and improve the flexibility of the aged binder. Rejuvenators are petroleum or bio-based oils with chemical and physical characteristics selected to restore properties of the aged asphalt binder in the surface layer. Adding a rejuvenator to a fog seal reduces the likelihood of cohesive failure within the asphalt binder film and can slow the rate of aging caused by oxidation. For

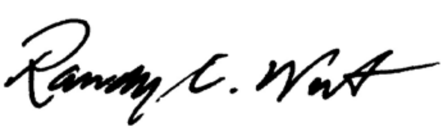
Letter from the Director

Roads of the Future

As a child of the 1960s, one of my favorite Saturday morning cartoons was The Jetsons. George Jetson and his family of the future lived in an apartment building perched in the sky, had a robot maid and a talking dog, and drove a flying car that folded into a briefcase. The flying car was the thing that really fired up my imagination. In my teenage years, I devoured issues of Popular Mechanics magazines featuring such futuristic concepts. A recent Google search of "flying cars" revealed an amusing list of attempts dating back about 100 years as well as ongoing efforts of numerous enthusiasts, entrepreneurs and scamsters.

I'm glad that there are people out there still working on that dream, and I hope they can turn it into a feasible reality in my lifetime. In the meantime, I'll keep working on roads. There are plenty of intriguing ideas to explore for the roads of the future. Fascinating concepts like roads that will charge electric vehicles as they travel at highway speeds, roads made of solar panels and roads made of plastic have captured a great deal of attention through social media. To be honest, I'm skeptical that some ideas will be economically feasible or able to hold up to the wear and tear of heavy traffic and extreme weather while providing good skid resistance.

At NCAT, we love doing research that pushes the envelope on sustainable pavements because these innovations consider environmental, economic and societal benefits. There are plenty of practical ideas for combining recycled materials, perpetual pavements and porous asphalt pavements that could be just as economical but last longer than the pavements of today. Although technology is advancing faster and faster, even if they get flying cars figured out, I'm betting it'll be a bit longer to get flying trucks working, ensuring that pavements will be around for many more decades.



Randy C. West, Ph.D., P.E. | Director & Research Professor

optimal restoration of the aged asphalt binder, consideration should be given to the chemical composition of the rejuvenator rather than just its capacity to reduce the viscosity of the aged binder. Furthermore, the degree of diffusion of the rejuvenator into the aged binder is of utmost importance since it allows chemical changes to take place that affect the physical properties.

Although rejuvenators can be categorized based on the material source or manufacturing process (i.e., aromatic oils, naphthenic oils, paraffinic oils, tall oils and fatty acids), it is also important to differentiate among products based on their chemical fractions. The composition of an asphalt binder is often defined by its so-called SARA fractions: saturates (S), aromatics (A), resins (R), and asphaltenes (A), which have increasing molecular polarity (saturates have the lowest and asphaltenes the highest). Often, asphalt is described as a colloid that consists of dispersion of asphaltenes in an oily matrix constituted by saturates, aromatics, and resins. Asphaltenes are stabilized in crude oils by natural resins, which are surfactant-like agents.

- Rejuvenators that are most compatible with the aromatics of the asphalt binder will reduce the viscosity and modulus of the asphalt binder through lowering the viscosity of the continuous solvent phase.
- Rejuvenators that have affinity for various fractions of the asphalt binder will reduce the viscosity of the binder through restoration of the original binder asphaltenes to maltenes ratio (i.e., the asphalt chemical fractions).
- Rejuvenators that exhibit low compatibility with the aromatics, asphaltenes and resins fractions of the asphalt binder, due to the presence of paraffinic and saturated materials with high crystalline fractions, will reduce the modulus of the binder. However, with aging, these components can increase the colloidal instability of the asphalt binder resulting in the precipitation of the asphaltenes.

An important factor when considering rejuvenating fog seals is the fact that these products will immediately decrease the skid resistance of the pavement. Rejuvenating seals should be selected as a treatment for pavements that have age-related distresses associated with stiffening of the asphalt binder. The curing time of a rejuvenating fog seal product, and its effect on friction, is influenced by the application rate, the existing pavement surface condition, and weather conditions at the time of the application. Therefore, traffic control and temporary reduced speed limits are often necessary after application for safety and to protect the integrity of the applied treatment.

As part of the current research cycle at the NCAT Test Track, the Mississippi and Tennessee Departments of Transportation have both sponsored rejuvenating seal experiments. NCAT conducted a preliminary screening study to evaluate seven rejuvenating seals to determine which products would be used on the Test Track sections (Table 1). The products were applied over an asphalt surface layer (asphalt content = 6.8%) with a mix of gravel aggregate constructed for the Test Track in 2012.

A modification of the Federal Aviation Administration's procedure P-632 (Bituminous Pavement Rejuvenation) was used to evaluate the rheological properties of the extracted binders two and four weeks after the application of the seven products. A schematic of the testing matrix utilized in this study before and after the application of the rejuvenating seal products is shown in Figures 1 and 2, respectively.

Pavement surface friction characteristics collected with the Dynamic Friction Tester 3, 24, and 96 hours after the applications of each treatment were also used in the screening process. Furthermore, friction tests after traffic

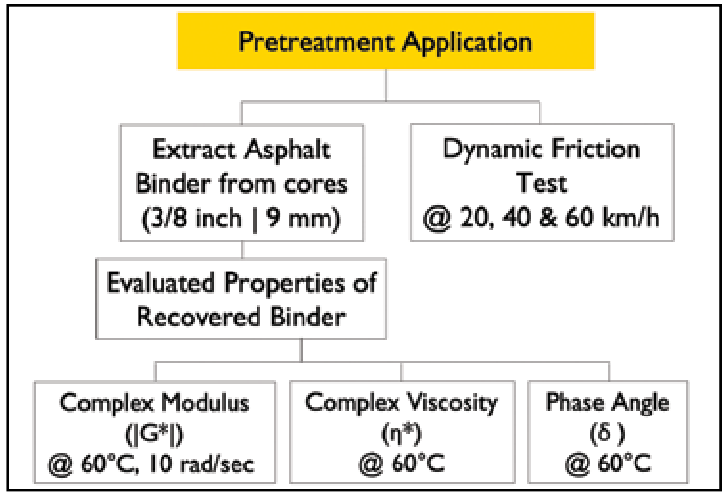


Figure 1. Testing matrix performed before application of the rejuvenating seal products.

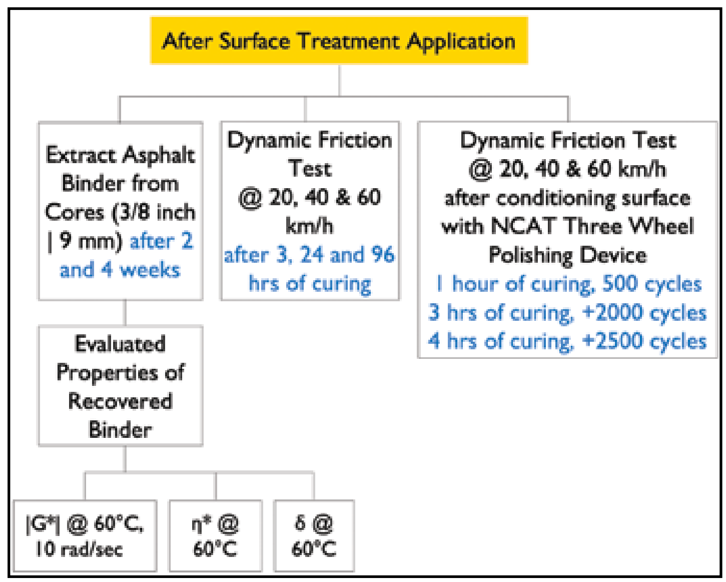


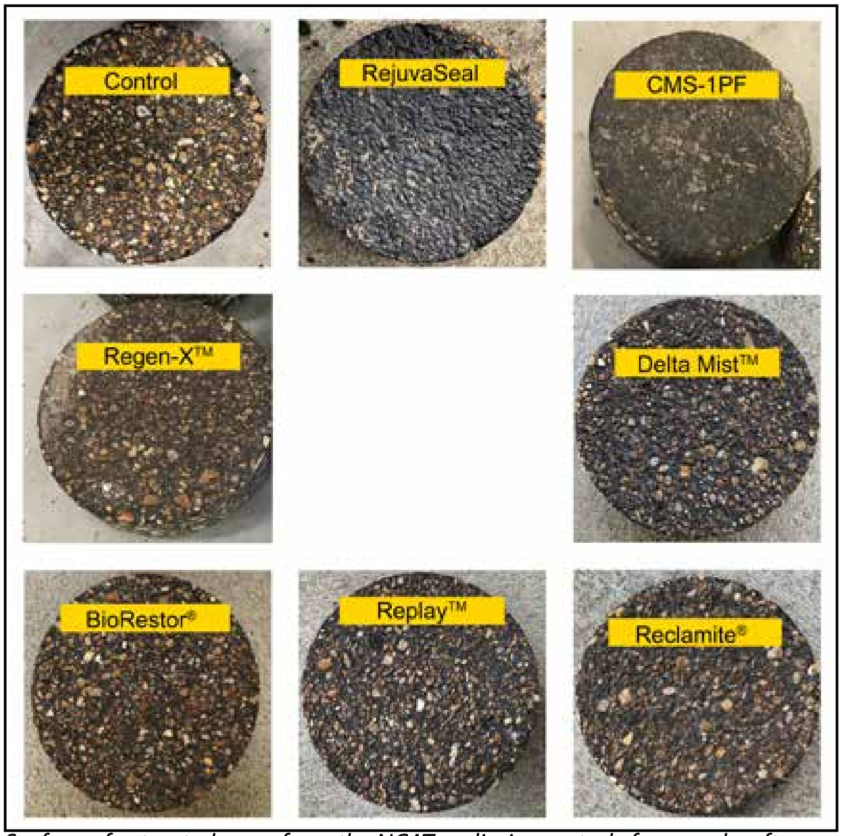
Figure 2. Testing matrix performed after application of the rejuvenating seal products.

Table 1. Rejuvenating products used on the NCAT screening study.

Surface Treatment Product	Composition	Product Use by Manufacturer Recommendation	Application Rate (gal/yd^2)	Dilution Rate
CMS-1PF	Hybrid emulsion containing polymer-modified asphalt base and rejuvenator	Rejuvenating fog seal, bond coat or cold pour crack filler	0.08	30% residual
ReGenX™	----	Age-regenerating surface treatment	0.07	2:1
RejuvaSeal	Aromatic oils & solvents	Asphalt rejuvenator for revitalizing, sealing and protecting asphalt pavement	0.06	100% residual
Delta Mist™	Plant-based rejuvenator	Topical rejuvenating seal	0.10	30% residual
BioRestor®	Bio-based rejuvenator	Construction seal	0.03	1:1
RePlay™	Polymers and soybean rejuvenator	Surface seals	0.015	100% residual
Reclamite®	Maltene-based from napthenic crude base	Asphalt pavement rejuvenator	0.08	1:1

simulated with the NCAT Three Wheel Polishing Device were also conducted.

The seven rejuvenating seal products were ranked based on their rheological properties and friction test results (Table 2). It is important to mention that this classification was based on testing of each product applied to only one pavement surface (i.e., one base binder, one aggregate type, and one mixture design). Different base binders, aggregates, and mix designs could potentially alter this classification. The results were presented to MDOT and TDOT to assist in the decision-making process for which rejuvenating seal products to use on their respective test sections. The Mississippi DOT selected ReGenX™ and Delta Mist™ to be evaluated on its S3 Test Track section. The Tennessee DOT selected Reclamite® and an experimental product, e-Fog S, to be evaluated on its S4 Test Track section. The field performance of these four rejuvenating fog seals will be evaluated for the entire two-year Test Track cycle as well as a more complete assessment of their effects on friction and rheological properties of the binders recovered from the top 9 mm of the pavement surfaces.



Surface of extracted cores from the NCAT preliminary study four weeks after application of the rejuvenating fog seal treatment.

From this study, three important observations were made:

1. Both dilution and application rates play a role in the effectiveness of the surface treatment in restoring the rheological properties of the aged binder. Rejuvenating seals with lower dilution ratios and higher application rates showed higher restoration of the binder rheological properties over the long-term.
2. For asphalt surfaces more than three years old, the complex modulus, |G*| (i.e., the stiffness) and complex viscosity of the binder extracted four weeks after the rejuvenating seal application must decrease by at least 40% from the pretreated values in order to maintain the effectiveness of the surface treatment.
3. To ensure safety, the coefficient of friction of the existing pavement surface should be measured before the rejuvenating seal treatment is applied. After three hours of curing, friction values similar to those prior to application should be obtained. After four days of curing, the rejuvenating seal should have no adverse effects on friction.

Table 2. Performance-based classification of rejuvenating products.

Grade	Surface Treatment Product
A	BioRestor®
	RePlay™
B	Regen-X™
	Delta Mist™
	Reclamite®
C	CMS-1PF
	RejuvaSeal

In summary, rejuvenating seals are a low-cost option for preventing or retarding the surface deterioration of pavements, practical in use since they do not require specialized equipment, and can be effective for restoring the surface condition of an existing pavement.

For more information, contact Raquel Moraes at moraes@auburn.edu

Development of a New Accelerated Lab Friction Testing Standard

Some highway agencies still rely on the British Pendulum (BP) test to qualify aggregates for asphalt pavement surface friction. Other agencies specify friction aggregate based on geology and/or mineralogy. Both approaches have allowed agencies to maintain an acceptable level of pavement friction long-term performance. However, the BP polishing and testing procedure evaluates a single size coarse aggregate and requires careful manual adjustment of the pendulum height to obtain the correct length of surface contact. Recent advances in laboratory polishing and friction testing now provide a better assessment of friction that considers the entire gradation in an asphalt mixture rather than a single aggregate source.

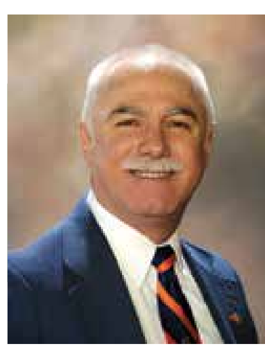
The Dynamic Friction Tester (DFT) gives a better assessment of the friction of a pavement surface. The DFT procedure, standardized in ASTM E1911, provides a more consistent measurement (no manual adjustment of the device before testing) and records friction over a range of speeds. NCAT developed the Three Wheel Polishing Device (TWPD) in 2006 to complement the DFT for measuring friction on asphalt mixtures.

The Maryland State Highway Administration modified the TWPD concept to use a large ring of a single aggregate on an epoxy substrate. After polishing with the TWPD, the ring of aggregate can be tested with the DFT to assess the aggregate's terminal friction value. Under Maryland's lead, a task group of AASHTO agency representatives and NCAT researchers are developing a new standard test procedure utilizing the TWPD and DFT. This standard will provide equipment requirements and testing procedures to rapidly evaluate an aggregate source or asphalt surface mixture for long-term friction performance. In addition to the TWPD and DFT, the equipment includes an aggregate specimen preparation device consisting of a rigid mold for the single aggregate procedure. The mixture specimen preparation procedure will permit any slab compaction procedure that produces the required size with a smooth surface compacted to a uniform target density. The testing procedure for aggregate polishing and asphalt mixture polishing are slightly different but involve the same TWPD. Both procedures use the DFT for measuring friction.

This new friction testing protocol allows an agency or aggregate supplier to determine the long term (terminal) friction properties of any aggregate or asphalt mixture in about one week for a cost of less than $5000. A few agencies have used this system to assess the friction performance of aggregate blends for surface mixtures at a substantially lower cost and much shorter time period compared to full-scale field test sections with no risk to the traveling public. Contact NCAT Lab Manager Jason Moore at moore02@auburn.edu for more details and a quote from our lab for testing your mixture.

British Pendulum Tester.

Dynamic Friction Tester (left) and NCAT Three Wheel Polishing Device (Right).



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Crack Sealing: A Cost-Effective Option for Extending Pavement Life

Cracking is a primary mode of distress in flexible pavements, and if left untreated, it may lead to accelerated deterioration and potholing, further reducing pavement serviceability. Cracks can be sealed as part of a pavement preservation program to prevent water infiltration and loss of load-carrying capacity, either as a stand-alone treatment or in combination with other preservation activities.

NCAT's Pavement Preservation Group study has been evaluating the performance of crack sealing treatments since 2012. There are three pairs of test sections on Lee Road 159 (NCAT's low-volume test site) that can be directly compared to assess the effect of crack sealing, as shown in Table 1.

Crack sealing was performed in three of the test sections, one as a stand-alone and two in combination with other surface seals. In all cases, the material used was an asphalt-based product applied hot as specified in ASTM D6690. In the inbound lane, cracks were routed and cleaned by compressed air and heat lanced prior to sealing with a reservoir configuration. In the outbound lane, cracks were only cleaned by compressed air and heat lanced before being filled using an overband configuration.

Prior to treatment application, existing cracking was mapped and quantified for all test sections. In general, crack sealing was applied to sections with a higher amount of cracking compared to their counterparts, which only received a surface treatment. Since then, cracking performance has been monitored periodically among other indicators. The results show that reappearance of cracking has been significantly delayed in sections that were treated with crack sealing.

Figure 1 shows the amount of cracking in each section after more than six years of service compared to the pretreatment condition (difference = current – pretreatment). While non-sealed sections have developed 12 to 33% of additional cracking compared to their initial condition, crack sealed sections developed less than half of that amount. Furthermore, in the case of the chip seal with crack sealing, the section has not yet returned to its pretreatment cracking level.

Table 1. Pavement Preservation Group test sections on Lee Road 159.

Treatment Type	Test Sections
Stand-alone crack seal	Control
	Crack seal
Chip seal	Chip seal
	Chip seal + crack seal
Micro surfacing	Micro surfacing
	Micro surfacing + crack seal

As expected, crack sealing has not affected pavement rutting and has not had an effect on IRI during the first six and a half years since treatment.

The benefits of crack sealing can easily be identified from a visual assessment (Figure 2). Testing with a falling weight deflectometer has also been performed periodically to monitor the integrity of the pavement structure, which uses deflection basin parameters to characterize the structural condition of pavement layers. In general, treated sections remain structurally sound with some exceptions in the stand-alone crack sealed section. Better results have been obtained when combining crack sealing with other surface treatments.

From the results obtained to date, it can be concluded that the use of crack sealing as part of a preservation treatment can successfully extend pavement life. The benefits ultimately depend on the initial condition of the pavement and are evident in the amount of cracking developed over the study period and the overall structural condition. To date, the overall pavement condition of the test sections can be classified as "good" to "fair". Data collection and analysis efforts will continue in the ongoing Pavement Preservation Group study with the objective of determining the life-extending and condition-improving benefit of all treatments based on initial condition, traffic level, and climate.

For more information, contact Adriana Vargas at vargaad@auburn.edu

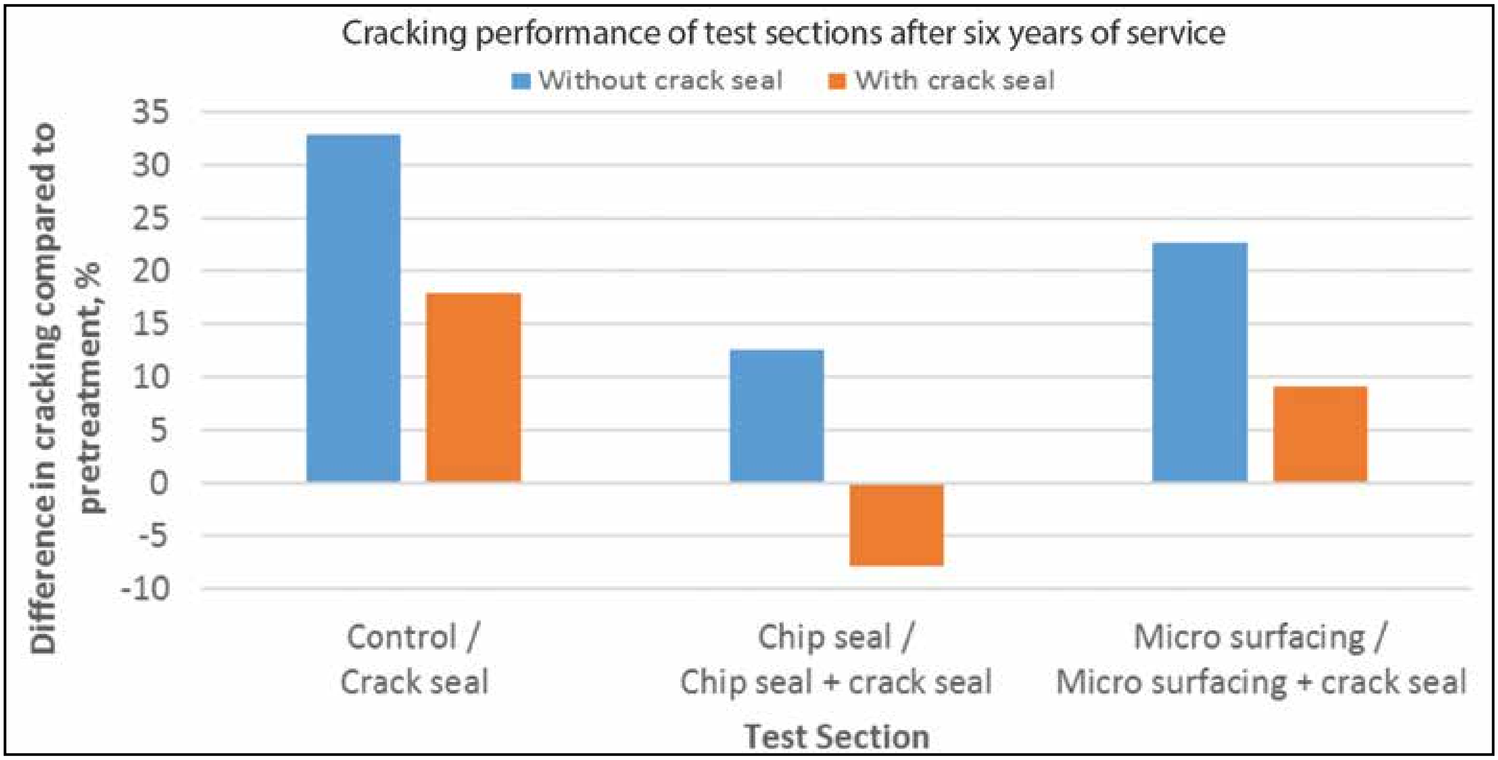

Figure 1. Cracking performance of test sections after six years of service.

Figure 2. Micro surfacing sections: stand-alone (left) and with crack sealing (right).

Cold Recycled Asphalt Mix Design

In cold central plant recycling, the asphalt recycling takes place at a central location using a stationary cold mix plant.

Cold in-place recycling (CIR) and cold central plant recycling (CCPR) are proven, cost effective and highly sustainable rehabilitation or reconstruction techniques for asphalt pavements. Cold recycled mixtures are primarily composed of reclaimed asphalt pavement (RAP) and are produced at an ambient temperature; thus, these techniques require significantly less energy to produce resulting in and generating far less greenhouse gas emissions than traditional rehabilitation methods. CIR and CCPR mixtures require a small amount (2-2.5% by weight) of foamed or emulsified asphalt binder and water to achieve an optimum density and particle bonding. In many cases, these mixtures also include an active filler (lime, cement, or other cementitious material) to enhance short-term and long-term stiffness.

Researchers at NCAT recently prepared a standard for cold recycling mix design with foamed asphalt, which has been published as AASHTO PP 94, Standard Specification for Determination of Optimum Asphalt Content of Cold Recycled Mixture with Foamed Asphalt. This standard specifies the requirements for material selection and documents the procedures to determine the amount of multiple binder components. The key steps of AASHTO PP 94 are highlighted as follows.

1. The RAP is compacted by modified Proctor at different water contents. The optimum water content is determined at the maximum dry density.
2. The RAP at the optimum water content is mixed with at least three trial foamed asphalt contents. An active filler is often added in this step to improve strength, rutting resistance, and moisture resistance. Hydrated lime, if used, is typically added at 1.0-1.5% by dry weight of RAP. Portland cement, if used, is typically kept between 0.25-1.0% by weight of RAP. Higher cement contents can be detrimental to performance.
3. The cold recycled mixture specimens are compacted with either a Superpave gyratory compactor at 30 gyrations or by Marshall hammer to 75 blows per side. Laboratory samples compacted using these two methods have provided density results comparable to those of field cores.
4. After compaction, the specimens are cured in a forced draft oven at 40 ± 1°C for 72 hours and then cooled to room temperature (i.e., 25 ± 1°C) for 24 hours. Research at NCAT has shown this curing protocol adequately reflects the strength gain of cold recycled foamed asphalt mixtures after 100 days of curing in the field.
5. The cured specimens are then divided into two subsets of three specimens each. One subset is soaked in the water bath at 25 ± 1°C for 24 hours, while the other subset is left in dry condition.
6. In the last step, indirect tensile strength (ITS) tests

are performed on the specimens. The optimum foamed asphalt content is defined as the minimum binder content to meet the mixture strength requirement shown in Table 1.

In 2015, NCAT used this mix design approach for the construction of one CIR and one CCPR test section on US 280 in Lee County, Alabama. Both sections have a four-inch cold recycled layer and a one-inch Superpave mix overlay. For the CIR mixture, the foamed asphalt content was 1.8% and the total water content was 4.9%. For the CCPR mixture, the foamed asphalt content was 2.2% by weight of dry RAP, and the total water content was 7.2% by weight of dry RAP. Type I/II Portland cement was added at 1.5% for both CCPR and CIR mixtures. This was higher than the suggested maximum cement content in AASHTO PP 94 but it was necessary to meet the dry ITS requirement.

Table 2 shows the laboratory test results of these mixtures. As presented, the designed CCPR mixture had a higher rutting resistance but less cracking resistance than the CIR mixture. As of February 2019, these two test sections have carried over 3.5 years of traffic with an estimated 2.3 million ESALs with no cracking and less than 0.25-inches of rutting.

NCAT researchers also completed a study to evaluate different active mineral fillers on the strength of cold recycled asphalt mixtures. The four fillers evaluated were Portland cement, hydrated lime, Class C fly ash, and baghouse fines. The results indicated that mixtures with cement and baghouse fines had higher dry ITS than those with hydrated lime and Class C fly ash, but mixtures with cement and hydrated lime had higher wet ITS. Cement was the best overall mineral additive in terms of improvements to both dry and wet ITS. The study also found that sufficient moisture was needed to increase hydration of cement, thereby enhancing the strength of cold recycled asphalt mixtures.

Cold in-place recycling involves the same process as cold central plant recycling except that it is performed in-place by a train of equipment.

Table 1. Cold recycling mixture strength requirements.

Test Method	Criteria	Property
ITS, dry subset	Minimum 45 psi	Cured strength
Tensile Strength Ratio	Minimum 0.70 (cement)	Resistance to moisture induced damage
	Minimum 0.60 (hydrated lime)	
	Minimum 0.60 (no additive)	

Table 2. Laboratory test results of cold recycled foamed asphalt mixtures.

Test Method	Test Parameter	CCPR-Foam	CIR-Foam
Indirect Tensile Strength	ITS (psi)	52.2	69.5
Tensile Strength Ratio	TSR (%)	92.1	98.8
Resilient Modulus	Resilient modulus (ksi)	432.2	449.9
Flow Number[1]	Plastic strain @20,000 cycles (με)	18,805	85,687
Texas Overlay	Number of failure cycles	103	141

Note: [1] Flow number test was conducted at 54.5°C with 70 psi deviatoric stress and 10 psi confining stress.

For more information, contact Fan Gu (left) at fzg0014@auburn.edu or Benjamin Bowers (right) at bfb0014@auburn.edu.

Micro Surfacing Improves Pavement Performance on Lee Road 159

Overall condition of scrub cape seal on Lee Road 159.

As agencies face the challenge of maintaining their existing infrastructure with limited resources, pavement preservation treatments have gained popularity as a cost-effective alternative for extending pavement life. Micro surfacing is a pavement preservation treatment that can be used to protect the pavement structure from moisture and correct minor surface defects. As with other preservation treatments, performance of treated sections depends in great part on proper candidate selection and timely intervention. Estimates for pavement life extension typically range from four to seven years; however, the criteria for defining performance varies among sources.

As part of the NCAT-MnROAD Pavement Preservation Group (PG) Study, six micro surfacing test sections were placed on Lee County Road 159, a low traffic volume road located in Auburn, Alabama. Treatments included single, double and cape seal applications and have been monitored periodically since 2012 to assess structural condition, surface distress, and ride quality. In addition, two sections were left untreated to serve as control. Table 1 provides a description of the test sections.

A Type II micro surfacing treatment was designed for all applications on Lee County Road 159 following the guidelines from the International Slurry Surfacing Association (ISSA). The mix included limestone aggregate, portland cement as the mineral filler, and a CSS-1HP asphalt emulsion, and was placed at a target application rate of 18 to 20 lb/yd^2.

Surface Distress

As sections approach their seventh year in service, the main type of distress observed has been cracking. Even though micro surfacing is not considered a crack mitigation treatment, its application has improved cracking performance compared to the control sections, as shown in Figure 1. While the control sections have deteriorated rapidly, treated sections have developed far less cracking since the treatments were constructed. Furthermore, the sections can be separated into three groups based on performance: untreated, single layer applications, and multi-layer or cape seal applications. As expected, more robust treatments have resulted in improved cracking resistance.

To provide a fair assessment of treatment performance, it is important to take into account the condition of the pavement at the time of application. Multi-layer and cape seal applications have not yet returned to their pretreatment level of cracking and remain in good condition, with less than 5% cracking by area. Single-layer applications have over 20% cracking. However, the section that included crack sealing exhibited a significantly higher amount of pretreatment cracking. When crack sealing was used in combination with micro surfacing, the test section that started with 18% cracking (pretreatment) increased to 27% after more than six years of service, for a change of only 9%. On the other hand, the stand-alone single layer micro surface increased from 5% pretreatment cracking to 28% currently, for an increase of 23% cracking over the study period.

Rutting has not been an issue for the sections on Lee Road 159. Pretreatment levels ranged between 4 and 7 mm, which is considered good to fair condition. On average, treatments were effective in correcting these minor levels of permanent deformation, and rut depths are under 5.5 mm after over six years of service.

Ride Quality

Prior to treatment application, most test sections had a good ride quality, with IRI values under 95 in/mi. Little variation has been observed in roughness over the course of more than six years, with sections maintaining a relatively constant IRI.

Table 1. Cold recycling mixture strength requirements.

Treatment	Description
Single micro surface	Single layer Type II micro surface
Micro surface over crack seal	Single layer Type II micro surface placed after crack sealing
Double micro surface	Double layer Type II micro surface
Cape seal	Single layer Type II micro surface placed over single layer chip seal
Fibermat® cape seal	Single layer Type II micro surface placed on fiber membrane reinforced chip seal
Scrub cape seal	Single layer Type II micro surface placed over scrub seal

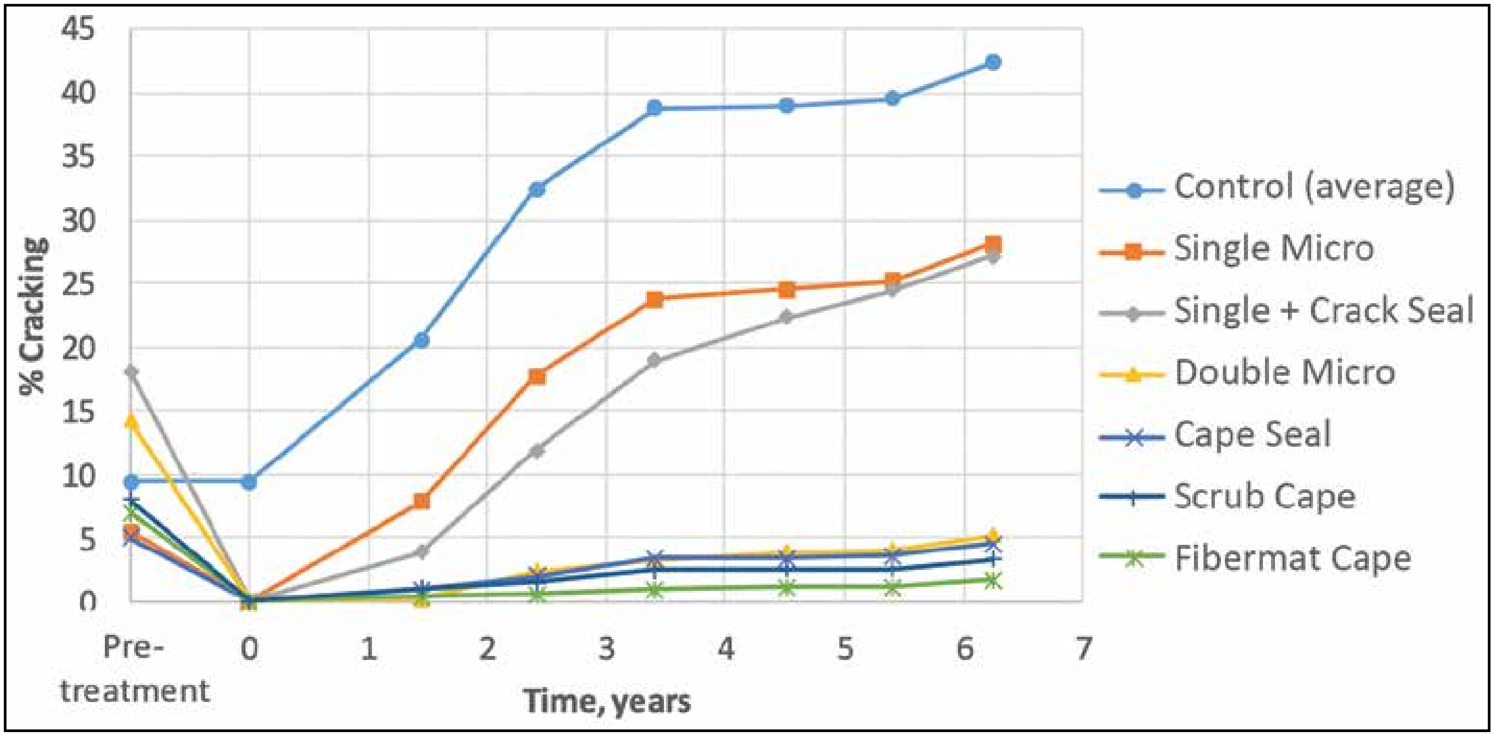

Figure 1. Cracking progression over time.

Structural Condition

Periodic falling weight deflectometer (FWD) testing is performed in the test sections to assess the structural health of the pavement. Although preservation treatments are not generally used to improve structural capacity, structural condition is monitored over time to determine if the treatments affect the structural condition. The micro surfacing sections on Lee Road 159 have been successful in protecting the structural integrity of the pavement without significant variations in pavement deflections over time.

As the PG study begins another cycle of data collection, the results observed over the first six years are promising. Sections treated with micro surfacing show improved performance compared to the control sections and have been effective in extending pavement life.

While Lee County Road 159 has the oldest test sections of the PG Study, additional treatments were applied on US 280 in Alabama in 2015, as well as on CSAH-8 and US 169, near Pease, Minnesota in 2016, providing a range of conditions that cover low and high traffic volumes in both southern and northern climates. Results in the upcoming years will provide valuable information that will help agencies estimate the performance of their treated pavement more accurately according to their local conditions.

For more information, contact Adriana Vargas at vargaad@auburn.edu

Where Are They Now?

Our alumni have a lifelong connection to NCAT. Whether it's the relationships they built, practical skills they developed or the world class education they received, each graduate takes something special from their experience at Auburn. In this issue, we reconnect with Angela (Priest) Fannéy, John Haddock and Mike Law to learn more about their days at NCAT and the routes they've taken since graduation.

Angela (Priest) Fannéy

Angela Fannéy wanted to be a civil engineer since her sophomore year in high school. Now a vice president at Kimley-Horn and Associates in Atlanta, Georgia, she reflects back to her time at NCAT as being a fundamental part of her successful career.

"I was in Dave Timm's undergraduate pavement class and I got a job working at the Test Track in the summer of 2003," said Fannéy. "It was hard work, but it was a lot of fun."

Fannéy stayed at Auburn to pursue a master's degree, which allowed her to finish the complete cycle of testing at the track. "I was able to see how we develop the test sections, build instrumentation physically with my hands, conduct mechanistic-empirical research and then present the findings to the NCAT steering committee," said Fannéy. "I also helped as we were trying to raise funds to develop the next research cycle. Those presentation and selling skills were more beneficial than I realized at the time."

Angela Fannéy (left) with her mentor Emmy Montanye (right) at the Mercedez-Benz Stadium in Atlanta, Georgia.

In her current role, Fannéy leads site civil consulting services for high density urban commercial redevelopment including retail and office spaces, apartments and sports facilities. She enjoys the challenge of collaborating in a multidisciplinary team environment and getting out of her comfort zone. "I work for a firm that prides ourselves in saying yes to what others say no to," she said. "Whether it's finishing a project in a tight time frame or just having the opportunity to work in a team with architects, landscape architects and engineers to solve complex problems."

Her most high-profile project, the Mercedes-Benz Stadium, was on the world stage earlier this year as home to Super Bowl LIII. Fannéy served as project manager of the civil engineering design for the LEED platinum building, including an innovative storm water runoff system to capture rainwater for reuse in landscape irrigation and the mechanical system's heating and cooling towers.

Fannéy's hopes for future civil engineers is that they recognize the sweat and sacrifice that success demands. "There is no secret to success other than hard work, curiosity and communication," she said. "I saw that in action at NCAT from the truck drivers, everyone working in the lab and the engineers. My experience at the Test Track provided the perfect foundation for a rewarding career."

John Haddock

John Haddock (seated) with his family in December 2018.

Building relationships requires authenticity, openness and commitment. For John Haddock, civil engineering professor at Purdue University and director of the Indiana Local Technical Assistance Program, many of the connections he's made through NCAT have endured throughout his career path.

Haddock earned his bachelor's and master's degrees in civil engineering from Purdue and was working for Heritage Research Group when he caught the attention of then NCAT director Ray Brown at a Transportation Research Board Annual Meeting. "Ray needed a research engineer who was familiar with stone matrix asphalt, and I was working on some of its early incarnations in the Midwest," Haddock explained.

Married and with three children, the family moved to Auburn, Alabama in 1993 where he worked full time at NCAT as a research engineer while pursuing his doctorate. "I have very fond memories of the time I spent at Alabama and NCAT," said Haddock. "It jumpstarted my career. When people in our industry find out that you worked at NCAT, it's kind of a big deal. And the fact that I finished my Ph.D. under Ray's tutelage didn't hurt, either."

After earning his PhD and welcoming the birth of a fourth child, Haddock returned to the north. He's since worked for the Indiana Department of Transportation, the Asphalt Institute and Purdue University, where he has taught for the past 19 years.

Haddock's work has taken him to six of the seven continents of the world, and his path often crosses with NCAT Director Randy West, recently retired training manager Don Watson, and fellow alumni Rajib Mallick and Shane Buchanan. His research is focused on increasing the sustainability of our nation's infrastructure and better relating laboratory test results to the field performance of asphalt pavements, which has led to numerous standard test methods and materials specifications.

When Haddock isn't working, he enjoys spending time with his family. "We have two grandkids and one on the way," he said. "It's the best part of life."

Mike Law

As vice president of materials at Bowling Green-based Scotty's Contracting & Stone, Mike Law is continually working to get better, longer lasting pavements in Kentucky. A leading asphalt and crushed stone producer in the state, Scotty's produces over 1.5 million tons of asphalt and crushes over one million tons of limestone aggregate each year.

Mike Law on the job with Scotty's Contracting & Stone.

"Scotty (James Scott) was looking for an engineer to head up his quality control division," said Law. "He got in touch with Don Brock at Astec Industries, who then referred him to Ray Brown. He knew that the best place to find a young engineer was at Auburn. I'm greatly appreciative of my association with NCAT, especially since it's opened so many doors and given me credibility throughout my career."

Law began working part-time in the NCAT lab during his junior year as an undergraduate in 1995 and continued with a research assistantship while pursuing his master's degree, which he received in 2000.

"NCAT gave me the technical and engineering basis I would need to work with asphalt paving contractors," said Law. "I was able to get an incredible hands-on experience and background of the materials side of the asphalt business."

Law lives in Kentucky with his wife, who he met while studying at Auburn, and their four children. He currently serves on boards of the Plant Mix Asphalt Industry of Kentucky and the Kentucky Crushed Stone Association and chairs the technical committees for both associations. He also serves as vice chair of the NCAT applications steering committee.

"Throughout my career, I've really been able to appreciate the incredible reputation that NCAT has in the asphalt paving industry," said Law. "It's the leading institution for asphalt pavement research and NCAT is constantly improving the quality of the roads in this country through its research, outreach and education."

Don Watson Inducted into NCAT Wall of Honor

Friends, family and colleagues gathered on Friday, Feb. 28, 2019 to celebrate the career of NCAT Training Manager Don Watson and his induction into the NCAT Wall of Honor. Stories were shared, best wishes were made and a few tears were shed during the retirement celebration.

Don came to NCAT in 2001 after a 32-year career with the Georgia Department of Transportation. As a research engineer at NCAT, Don was the principal investigator on a diverse list of projects ranging from stone matrix asphalt, open graded friction courses, Superpave refinements and thermal segregation. He also made significant contributions to topics such as warm mix asphalt, recycling, and mechanistic pavement design. His practical research has made a positive influence on specifications in numerous states and will have a lasting impact of the quality of asphalt pavements for years to come.

Perhaps the most significant contribution that Don has made to the industry and NCAT's mission is his work as manager of NCAT's training program. Don is an outstanding instructor, drawing on his decades of field experience, sharing his genuine interest to improve pavements, taking care to explain concepts in ways that are easy for all to understand, and inspiring participants to ask questions and apply the lessons they've learned to make better asphalt roads. During his time as training manager, the program greatly expanded in technical content and the number of people taught through the courses. He has helped grow NCAT's reputation worldwide through training groups from South Korea, Russia, Mexico and Nigeria, as well as traveling to instruct ongoing training programs in Puerto Rico and Qatar.

"Don Watson is a man of true character," said NCAT Director Randy West. "It will be impossible to replace his 49 years of experience in the industry, but the biggest void that he'll leave is the daily influence that he has on the NCAT family."

After retirement, Don still plans to work part-time as an instructor and continue his service to the industry through his work in the NAPA Quality Awards program.

Don Watson receives the Wall of Honor plaque from Chris Roberts, NCAT board vice-chair and dean of the Samuel Ginn College of Engineering at Auburn University.

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.

Ohio DOT has a micro surfacing bond research project that's looking at determining bond strength as well as if and how much (diluted) tack is needed. Phase 2 field trials are to be placed in Spring 2019.
-Eric Biehl, Ohio DOT

Asphalt Forum Responses

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

With the development of the regressed air void concept, balanced mix designs, and greater emphasis on higher field densities, the asphalt pavement community seems to be more comfortable with mixes designed to have less than the 4.0% air void target traditionally used for Superpave design. What is the minimum air void level for in-place compacted pavements at which the mix would not be acceptable for your organization?
-Don Watson, NCAT

Michael Stanford, Colorado DOT
Below 92%, would not be acceptable. Our specification requires a density of 92 to 96% of the daily theoretical maximum specific gravity.

Greg Sholar, Florida DOT
We currently require removal of asphalt that has an in-place density below 89.5% Gmm measured of roadway cores using vacuum drying. Our target densities are 93.0% Gmm for vibratory compaction and lifts greater than 1.0" thick and 92.0% Gmm for roadways with mandatory static compaction and/or layers 1.0" thick. FDOT is monitoring national research but has not made a decision to lower target design air voids to a level below 4.0%.

Rick Bradbury, Maine DOT
Our lower specification limit is 92.5% of Gmm for all dense-graded mixes, accepted using PWL. AQL = 90 PWL; RQL = 50 PWL. Based on research into permeability, in-place density <92.0 % Gmm is the point where permeability is unacceptable for 9.5mm - this increases for coarser mixes.

Kevin Kennedy, Michigan DOT
Michigan regresses mix designs to 3% air voids. We have a PWL specification for pay. We define spec limits for lab compacted air voids as ± 0.9%, and sublot rejectable quality limits of -1.5%, +2.0%.

Eric Biehl, Ohio DOT
In our current 446/447 (field cores for density acceptance) specifications, if the average of 10 mat cores is between 97.0 and 97.9% density then the contractor receives a 6% deduction in pay. For surface layers, an in-place density of 98.0% or greater would be removed and replaced; for other courses, a 40% deduction would be applied if the layer is left in place. Section 446 includes three "joint" cores in the average, and Section 447 has two tables (one for mat average density and the other for joints that's a PWL approach). Average mat densities for all of Ohio have been mid 93% for the past four to five years, so we most likely don't see those high of densities. We have talked about increasing our density acceptance values. Our mixes are designed at 4.0% or 3.5% air voids depending on mix type.

Cliff Selkinghaus, South Carolina DOT
We do not have a maximum for in place density. An average of 94.0% of Gmm or more receives a 5% incentive.

Howard J. Anderson, Utah DOT
The air void target in Utah is 3.5% at Ndesign. With our PG plus specification that requires all our binders to be modified, and with the Hamburg rut test in place, we allow in place materials to be compacted up to 97.5% of the Gmm. This is measured from cores. We made this change along with our longitudinal density specification a couple of years ago.

In theory, job mix plus/minus tolerances should be allowed to exceed the upper or lower limit of the specification band. However, there are local agencies in Hawaii that do not allow this when checking production mixes What is the policy in other states? Can the job mix formula +/- the tolerance exceed the upper or low limit of the specification band? What is the effect on the mix if either limit is exceeded?
Jon Young, Hawaii Asphalt Paving Industry

Michael Stanford, Colorado DOT
The quality level of all elements is constantly monitored. If the quality level drops below the tolerance, production may be suspended until the source of the problem is identified and corrected.

Greg Sholar, Florida DOT
FDOT has target gradation values on the mix design and PWL tolerances based on those targets during production for the -8 and -200 sieves (different sieve sizes apply for OGFC mixes). FDOT also has a master range, which exceeds the PWL limits, for the -200 sieve. If that master range is exceeded then an investigation occurs, which may include just a data examination of the other material properties, a follow-up sample, coring of pavement to determine material properties, or a combination of the above.

Rick Bradbury, Maine DOT
Maine DOT's specification requires that gradation tolerances (+/- from the JMF target) cannot exceed the Superpave control point limits. For example, for a 12.5 mm mix, the control point on the 9.5mm sieve is 90% maximum. If the production tolerance for the 9.5 mm sieve is +/- 5%, a contractor could design a JMF with a target % passing the 9.5 mm sieve of 89%, but the upper specification limit during production would be 90% passing, not 94%. This is to prevent contractors from designing what is essentially a 9.5mm mix when a 12.5 mm mix is specified in order to meet VMA requirements.

Kevin Kennedy, Michigan DOT
Michigan uses a PWL specification where exceeding those limits affects pay factors. There are also QC action limits, QC suspension limits, etc. to prevent a contractor from continually running outside of those tolerances without taking actions to correct the problem.

Greg Johnson/John Garrity, Minnesota DOT
If the specification limits are exceeded then a monetary deduction is applied; if extreme, the material must be removed and replaced.

Eric Biehl, Ohio DOT
Our mix gradation bands in our specification book are considered "design" gradation bands with a few exceptions. The mix design is required to meet the gradation band before we will approve it. During production, there are tolerances based on the approved job mix formula for gradation for four sieves that can exceed the "design" gradation band. For the No. 4 sieve, the mixture's macrotexture can be impacted if too large of a gradation change occurs (we have limestone and gravel mixes mainly). One of the exceptions is for 12.5 mm mixtures (used for heavy traffic surfaces). For this mix, the percent passing the No. 4 sieve cannot exceed 63% during production. The other item that limits P200 content during production is the fines to asphalt (dust to binder) ratio. A cheap way for contractor to get density/low air voids is to add dust.

Cliff Selkinghaus, South Carolina DOT
We are sticking with the USL and LSL for gradation only to be sure that we are getting the correct mix type. The binder content, air voids, and VMA may extend outside of the USL/LSL with the +/- tolerances applied. The main focus is to ensure that we get enough percent binder in our mixes, especially with higher recycled contents.

Our specifications require a thickness tolerance for all asphaltic concrete laid. If the thickness is not within the required tolerances, the layer is not accepted. Do any agencies have a method for rectification or acceptance of the works?
Wimal Silva, Sri Lanka

Michael Stanford, Colorado DOT
In Colorado, asphalt is paid by the ton. Our field engineers constantly check the yield (tons vs. area paved) to verify the thickness is correct. This is typically not a problem in our state.

Greg Sholar, Florida DOT
FDOT measures spread rate based on an average of five to ten truckloads of mix and then calculates daily averages. There are multiple steps along the way, but basically if the average spread rate differs by more than 5%, then monitoring occurs. If this happens for two days in a row, then shutdown occurs until the problem is identified. When an individual spread rate is beyond plus or minus 20% of the target spread rate, construction is halted and the unacceptable pavement is evaluated via coring to determine limits for removal and replacement, if necessary. Too thin of pavements is the biggest concern.

Kevin Kennedy, Michigan DOT
We pay for HMA by the ton so thickness is usually not an issue although we check yields in the field. On jobs where we pay by the square yard we do thickness checks and penalize accordingly.

Greg Johnson/John Garrity, Minnesota DOT
If the thickness exceeds planned thickness plus the tolerance, then materials placed in excess may be excluded from payment. If pavement thickness is below planned thickness, the engineer will decide on reduced payment under our standard unacceptable work specification.

Eric Biehl, Ohio DOT
We pay by the cubic yard so we typically get the thickness specified. If the layer is too thick (more CY than the plan quantity), then we just pay the plan quantity. In the rare situation where the layer is too thin, we would evaluate the pavement to make sure the pavement structure is adequate. If not, then the contractor is required to make corrections (another lift, mill/fill, or a combination of both).

Cliff Selkinghaus, South Carolina DOT
We specify a placement rate in pounds per square yard. The department's roadway inspector checks the placement rate every 200 tons placed and ensures that

the HMA contractor makes adjustments throughout the day to average out as close as possible to the contract placement rate (stay within the plan quantities).

Howard J. Anderson, Utah DOT

In Utah, if the cores show they are deficient in thickness by 0.25 inches or more, the contractor has to place another layer. I have copied language directly from our standard HMA specification for your use:

Thickness requirements are based only on mat cores. The thickness requirement may be waived when matching up to existing pavement, curb and gutter for pavement in or next to intersections.

The department accepts a lot for thickness when (1) The average thickness is not more than 1/2 inch greater or 1/4 inch less than the total design thickness specified, (2) No individual sublot shows a deficient thickness of more than 3/8 inch.

Excess thickness – the engineer may allow excess thickness to remain in place or may order its removal. The Department pays for 50% of the mix for material in excess of the +1/2 inch tolerance when excess thickness is allowed to remain in place.

Deficient thickness – place additional material where lots or sublots are deficient in thickness. The department pays for material necessary to reach specified thickness. The department pays for 50% of the mix for additional material over specified thickness necessary to achieve minimum lift thickness. Minimum compacted lift is three times the nominal maximum aggregate size.

Thickness tolerances established above do not apply to leveling courses. Check final surfaces in stage construction. Check thickness regularly with a depth probe and take corrective action as necessary for thin overlay pavement.

Specification Corner

Florida DOT

FDOT has changed the weighted percentage of roadway density for payment from 35% to 40%. This is an incremental step with a potential to go to 45% in two years. FDOT recognizes the importance of this material property and would like to see contractors achieve higher densities and a corresponding higher pay factor.

Maine DOT

Starting in 2019, all mixes will be designed at 65 gyrations. We do not see a large difference between 50 and 75 gyration designs, so this will simplify JMF management for the DOT and industry. Heavier traffic applications will use polymer-modified binder.

We are moving from QC testing/control charts on an individual project basis to running QC for the JMF regardless if project mix is delivered. This will be a more rational approach to QC.

We are eliminating the option to use PG 58-28 on certain projects. PG 64-28 will be the standard grade.

We are expanding the use of continuous thermal profiling.

We are adding Gmm to the properties that must be managed with a control chart to improve consistency.

Ohio DOT

We just released our 2019 Construction and Material Specifications Book, which includes our relatively new joint core acceptance. The new specification is section 447; it was previously Supplemental Specification 806.

The maximum % RAS has been reduced from 5.0% to 3.0% for mixes that do not contain RAP (currently no designs exclude RAP). However, when using RAS, no more than 25% RAP may be used. Also, RAS is no longer allowed in surface mixes. A few research projects guided us in this direction.

We have updated our mix plant calibration procedures (Supplement 1101) for drum plants, which requires at least two rates (low and high) compared to a single rate. We also added a new method for asphalt binder calibration.

We will soon be adding a supplemental specification for fog seals and void reducing asphalt membrane (VRAM) binder.

Utah DOT

We have replaced the direct tension test (DTT) for asphalt binders with the Delta T_c parameter of -1.0 or better required (one PAV) and a minimum stiffness requirement of 150 MPa for the first BBR beam. We have also increased our elastic requirements by 15% to bring the testing values closer to those with the DTT.

The DTT test has kept REOB in control (low amounts, 3% maximum) or entirely out of our market. Our goal with the new specification is to keep the same quality binders that we currently have.

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