

Asphalt Technology News

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How Effective is Crack Sealing?



Treatment of a Pavement Preservation Group Study test section on Lee Road 159.

Crack sealing and filling can be cost-effective treatments when applied while the pavement is still in a state of good repair. These treatments consist of applying a highly elastic material into pavement cracks to prevent or reduce the intrusion of water and incompressible materials. The benefits of crack sealing include decreasing further crack deterioration, protecting the pavement structure from moisture damage, and ultimately extending the pavement life. Although the expected life extension is typically reported to be between two to five years, the benefit obtained depends on several variables such as traffic, climate, and the condition of the pavement at the time of treatment.

Answering the question of how much life-extending benefit can be gained from crack sealing—and other preservation treatments—is the main objective of the

Pavement Preservation Group Study being conducted as part of the NCAT/MnROAD partnership. Thanks to the construction of full-scale test sections and periodic monitoring of pavement condition data, the study provides an ideal platform to quantify the benefits of preservation under different conditions.

The results discussed in this article are from test sections on Lee Road 159, a two-lane county road near NCAT that represents the low-traffic volume, warm climate portion of the research. Lee Road 159 has the oldest test sections in the study, which are now approaching eight years in service. A unique characteristic of this site is that it provides dead end access to a quarry and an asphalt plant, resulting in a high percentage of traffic with heavy loads. Although both lanes are subjected to the same traffic volume, traffic loads vary significantly as trucks travel unloaded

in the inbound direction (to the quarry and asphalt plant) and exit loaded in the outbound direction.

A subset of six test sections was selected to reflect potential differences in performance exhibited by pavements with and without crack sealing applied as a preservation treatment. The sections were divided into three categories, as shown in Table 1, to allow direct comparisons among pairs of treatments where the only difference in each pair is the application of crack filling or sealing. It should be noted that crack treatment varied by direction; cracks in the inbound lane were routed and sealed, while cracks in the outbound direction were filled using an overband method.

Each 100-foot long test section was further subdivided into 5 by 10 foot subsections used to quantify the life-extending benefit of the pavement preservation treatments as a function of initial condition. Subsections were classified as “good”, “fair”, or “poor” depending on the pretreatment percentage of area cracked, with “good” condition being less than 5%, “fair” between 5 and 20%, and “poor” condition over 20%. These category ranges were selected to be

consistent with the performance criteria established by the Federal Highway Administration to assess pavement condition as part of the National Highway Performance Program.

The long-term nature of this study is challenging since the primary variable of interest is the time to failure (in this case, failure being considered as reaching the “poor” category). Even after nearly eight years of service, some of the subsections have not reached failure. Fortunately, survival analysis is a statistical method that helps us overcome this obstacle because it allows the use of censored data (i.e. data in which the observed value is only partially known).

Survival analysis was performed on the Lee Road 159 data to generate survival curves, which show the survival probability over time. An analysis period of ten years was selected and the curves were used to compare each pair of treatments and calculate the life-extending benefit resulting from the crack sealing or filling treatment. While any survival rate can be used depending on the desired level of reliability, the median time to failure (MTTF) is typically used for this

Table 1. Pavement Preservation Group Study test sections

| Category | Treatment Description | |
|-----------------------------|------------------------------|------------------------------|
| | Inbound Lane | Outbound Lane |
| Stand alone crack seal/fill | Control | Control |
| | Crack seal | Crack fill |
| Chip seal | Chip Seal | Chip seal |
| | Chip seal + crack seal | Chip seal + crack fill |
| Micro Surfacing | Micro surfacing | Micro surfacing |
| | Micro surfacing + crack seal | Micro surfacing + crack fill |

Table 2. Life-extending benefit as a function of pretreatment condition

| Category | Travel Lane | Treatment Description | Life-Extending Benefit, Years | | |
|-----------------------------|-------------|--|-------------------------------|------|------|
| | | | Good | Fair | Poor |
| Stand alone crack seal/fill | Inbound | Control vs. crack seal | 7.7+ | 4.6 | 1.1 |
| | Outbound | Control vs. crack fill | 4.7+ | 7.3 | 2.1 |
| Chip seal | Inbound | Chip seal vs. chip seal + crack seal | 1.9 | 1.5 | 1.4 |
| | Outbound | Chip seal vs. chip seal + crack fill | 2.0 | 1.6 | 1.4 |
| Micro Surfacing | Inbound | Micro surfacing vs. micro surfacing + crack seal | Not significant | | |
| | Outbound | Micro surfacing vs. micro surfacing + crack fill | | | |

type of analysis. As shown in Figure 1, the life-extending benefit is calculated as the difference in MTTF between sealed and unsealed sections.

The results for each treatment pair as a function of pretreatment condition category are shown in Table 2. The results are also given by travel lane, which relates to both traffic loads and crack treatment.

As expected, the MTTF benefit obtained from crack sealing depends on the condition of the pavement prior to treatment application and was higher for pavements treated while in “good” condition. When used as a stand-alone treatment on a pavement in “good” condition, the life-extending benefit could not be calculated for the selected analysis period because the sealed sections are not expected to reach the median time to failure within 10 years; however, the MTTF is expected to exceed 7.7 years for the crack sealing treatment and 4.7 years for crack filling treatment. In this case, test sections in the outbound lane had better results despite the increased traffic loads, which may be an indication that crack filling was more effective than crack sealing.

If crack sealing or filling is used in combination with a chip seal, the life-extending benefit was similar in both travel lanes regardless of the differences in traffic loading and sealing technique. The benefits shown in Table 2, which range from 1.4 to 2.0 years, are only for the crack treatment and do not include the additional benefit provided by the chip seal.

The lack of statistical significance in sections that combined micro surfacing with crack sealing or filling was surprising. Nonetheless, these findings are tied to the way that condition categories are defined in the analysis. Particularly, for the “poor” condition category, which has a lower bound of 20%, both sections reached failure at around the same time, although

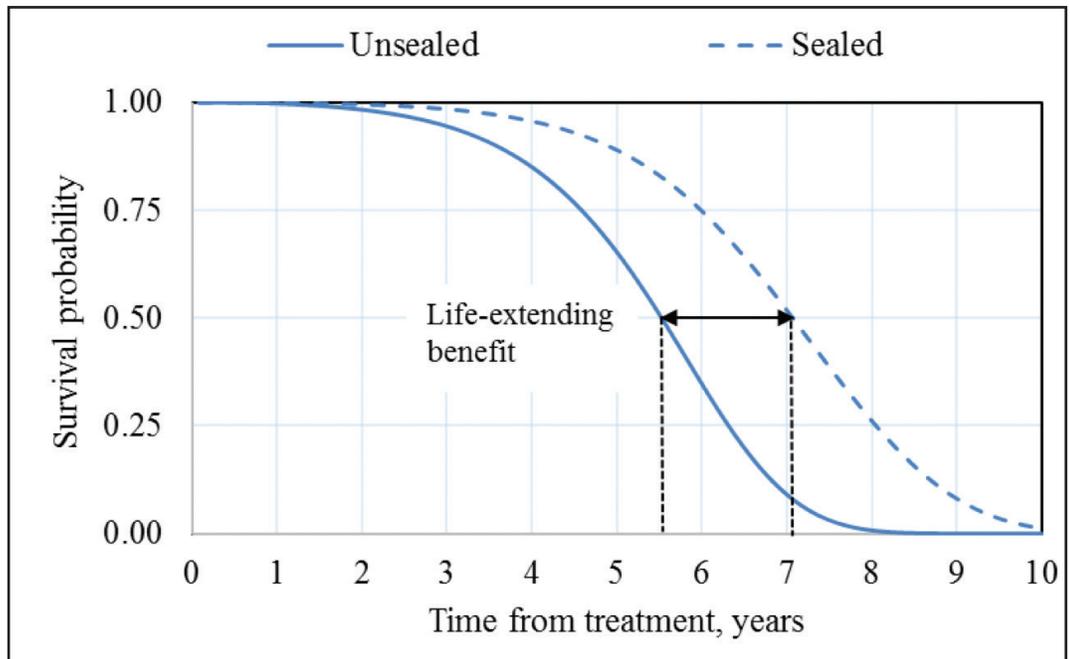


Figure 1. Life-extending benefit calculation

the average pretreatment cracking percentage was 21.4% for the micro surfacing section and 41.9% for the micro surfacing with crack seal/fill. This suggests that there is a benefit that could not be captured statistically, but as mentioned earlier, the condition ranges were selected to be consistent with the FHWA performance criteria.

As data collection efforts continue, the accuracy of results may be improved as the amount of censored data is reduced. Also, additional test sections were constructed on U.S. Route 280 near Opelika, Alabama in 2015, as well as on U.S. Highway 169 and County State Aid Highway 8 near Pease, Minnesota in 2016. These newer sections have been in service for a shorter period but will be analyzed in the same way to determine the effects of traffic and climate on the life-extending benefit of the treatments.



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



Message from the Director

The Long and Winding Road

The Beatles' *The Long and Winding Road* is one of my all-time favorite songs, partly because it's about a road—at least, sort of. Sir Paul's melancholy lyrics and tune uses the road as a metaphor for the journey of life through strife, sorrow, and loneliness back to a familiar path and destination.

Research is often a long and winding road, and sometimes it's a dead end.

The real joy of research is seeing a new technology make its way into mainstream practice. NCAT has been fortunate to play a significant role in the development and implementation of several asphalt pavement technologies through the past three and a half decades, and it's gratifying to see the success of technologies like the ignition method, stone-matrix asphalt, PCC pavement rubblization, thinlay mixes, and warm-mix asphalt that have been accepted into day-to-day usage across the country. NCAT doesn't deserve all of the credit—in some cases, our primary role has been to facilitate implementation through training.

Research and development of new technologies generally progress through numerous stages. In the world of asphalt research, some of the major steps include initial proof-of-concept lab testing, designed experiment lab-scale testing (typically to refine formulations and/or dosages), further lab testing to evaluate interactions with a broader range of mix components, plant trials, accelerated field testing, and construction and evaluation of field test sections. In some cases, it is also necessary to conduct studies along the way to make sure there are no harmful effects to workers and the environment.

It takes a long-term view with perseverance (and usually a big stack of Benjamins) to take a technology from the genesis of an idea all the way to implementation into routine use. Often, we're just not sure if the investment is worth the change from the status quo. A truly valid cost/benefit analysis of a new technology can't really be conducted until we have data about its effect on long-term performance and the full cost of the technology. Unfortunately, it typically takes half of a career to really see the impact of some changes.

Some researchers fall into the habit of referring to the results of lab tests or model predictions as "performance." True performance is what happens on the roads, highways, and airfields under real traffic and years of environmental exposure. When trial projects are built on real highways, the pavement research community typically only examines field performance for just a few years. That's not nearly long enough to quantify the full impact of a technology to determine if it really pays off. This is where the benefits of accelerated pavement testing really shine, especially accelerated pavement testing that involves the real impacts of aging. On the NCAT Test Track, we apply 16,000 axle loads (up to 20-kips) every day to achieve four times the loading of a "typical" interstate highway. We've learned that the environment also has profound impacts on how a pavement responds to loading through daily and seasonal changes in precipitation and temperatures that affect asphalt pavement stiffness, as well as aging effects that take years to manifest an impact on surface layers.

There are very few shortcuts we can take to prove out new pavement technologies. But with good experiments, documentation and a little patience, we are developing better tools to get us where we want to go faster, and possibly, make the long and winding road a little shorter.

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

2019 Research Review

NCAT released eight technical reports in 2019 covering a wide range of topics. A brief summary of each follows, and full versions are available for download free of charge at www.ncat.us.

NCAT Report 19-01: Preliminary Evaluation of Recycled Asphalt Shingles in Warm Mix Asphalt in Wilson, North Carolina

NCAT documented the production and construction of a demonstration project using post-consumer recycled asphalt shingles (RAS) and manufacturer waste RAS in warm mix (WMA) and hot mix asphalt (HMA) and evaluated their properties using a range of laboratory tests.

In the Hamburg test, the WMA mixes had statistically higher rut depths than the HMA mixes; however, all of the mixes had relatively low results. The Overlay Tester and the I-FIT results indicated that the mix containing post-consumer RAS and WMA had better cracking resistance than the mix containing manufacturer waste RAS produced at HMA temperatures. All mixes had similar results for thermal cracking susceptibility. At the time of the 14-month project inspection, all four mixes exhibited similar field performance with no differences evident due to the type of RAS or the use of WMA.

NCAT Report 19-02: FHWA Demonstration Project for Enhanced Durability of Asphalt Pavements Through Increased In-Place Pavement Density, Phase 2

A recent FHWA initiative focused on how to achieve higher in-place densities through improved compaction methods. The Phase 2 report includes best practices and provides specification examples.

The study documented field demonstration projects intended to help state highway agencies evaluate their current density requirements. Of the eight documented projects, six improved in-place density by at least 0.5 percent and all projects had at least one test section with an average in-place density greater than or equal to 94.0 percent. Methods used to obtain higher in-place densities generally fell into one of six categories: (1) including or increasing incentives and raising the minimum percent in-place density requirements; (2) better use of compaction equipment; (3) adjusting the asphalt mixture design to increase the asphalt content; (4) reducing variability; (5) following best practices; and (6) using new technologies.

NCAT Report 19-03: Best Practices for Determining Life Cycle Costs of Asphalt Pavements

State highway agencies continually face important financial decisions when planning a new or reconstructed highway. For example, what initial investment should be made? How much will be needed for maintenance? What construction materials should be used? The answers to these questions may surface in a life-cycle cost analysis, which estimates how much it will cost to build and maintain an asset over time. This report provides best practices to help highway agencies properly determine inputs for use in their life cycle cost analysis procedures and to calculate the life cycle costs of asphalt pavements.

NCAT Report 19-04: A Synthesis of Technical Needs of Asphalt Pavements for Local Roads

This synthesis of pavement engineering for low volume roads included a review of asphalt mix design guides, pavement design guides, and research reports, as well as a state of the practice survey to summarize current practices for designing low volume roads. The synthesis also identified common issues and knowledge gaps typically encountered when building and maintaining low volume roads.

Rural roads are often built with less-than-conventional design standards, resulting in road designs that are not optimally engineered. A proposed actions segment encourages agencies and industry to follow examples in the document in order to establish best practices for mixture design protocols and acceptance criteria.

NCAT Report 19-05: Three Wheel Polishing Device and Dynamic Friction Tester Accelerated Laboratory Friction Testing Repeatability and Reproducibility Study

This study examined the repeatability and reproducibility for a Three Wheel Polishing Device (TWPD) and dynamic friction tester (DFT) testing protocol for a proposed AASHTO standard to assist in implementing accelerated friction testing. The study evaluated slab compaction methods, TWPD polishing, and friction measurements with the DFT. Two laboratories used the same model of DFT but different models of the TWPD. Researchers found that the DFT did not influence the average of replicate friction measurements and different analysis methods provided comparable results. However, there was a significant difference between the friction coefficients measured by the two labs. Results also indicated that the compaction methods used in the labs did not create consistent slabs.

NCAT Report 19-06: Determining Initial Service Life for LCCA Using Comparable IRI as One of the Criteria

Since pavement smoothness is important to the traveling public, it should be a key factor in determining the timing for pavement rehabilitation. NCAT researchers evaluated data from the Long-Term Pavement Performance (LTPP) program to explore this issue.

LTPP data indicates that most asphalt pavements in the LTPP program were maintained or rehabilitated before reaching the mean international roughness index (MRI) threshold of 170 inches/mile currently suggested as the point where pavements are in poor condition by the FHWA Highway Performance Monitoring System guidelines. An MRI threshold of 120 in/mile is found to be more representative of the pavement roughness at the time of first intervention in the LTPP database. The ages of AC and PCC pavements at which their smoothness reaches 120 in/mile are similar for AC and PCC pavements.

NCAT Report 19-08: Mix Design Strategies for Improving Asphalt Mixture Performance

This report summarizes the findings from a literature review and a survey of State Asphalt Pavement Associations regarding adjustments to volumetric mix designs to improve asphalt mix durability. Three adjustments were identified as likely to provide the greatest improvement in pavement performance: (1) use more polymer modified asphalt binder; (2) increase the amount of new binder in a mixture by lowering the design air voids or increasing the minimum VMA requirement; and (3) increase in-place density by methods such as lowering Ndesign requirements. The report also briefly discusses how the Superpave5 mix design method, designed to improve in-place density, and the Bailey method, which can be used to better control the volumetric properties of asphalt mixtures, can have positive impacts on mixture performance when combined with the recommended adjustments.

NCAT Report 19-09: Quantifying Pavement Albedo

This report documents a study that measured albedo and other thermal properties of asphalt and concrete pavements at seven locations in the United States with a range of aggregate types, pavement surface ages, and climates. Results show that the albedo of all pavements change over time in an asymptotic fashion toward unique values for each site. An AC pavement albedo model was developed that reasonably predicted albedo over time based on pavement age and coarse aggregate color. The PCC albedo model, which included pavement age, coarse aggregate color, and surface texture, was unable to accurately predict albedo. Additional models reasonably predicted pavement thermal responses in warm, dry climates but did not adequately account for the influence of moisture and freezing climates. Pavement thermal properties were shown to affect pavement designs by as much as 15% based on AASHTOWare Pavement ME design results. Current highway sustainability rating systems have recognized the complexity of pavement albedo. Some systems only address qualitative cool pavement goals while others do not address albedo-related metrics or outcomes.

Insights Gained from Balanced Mix Design Workshops



NCAT Director Randy West leads a balanced mix design workshop at the Utah Department of Transportation's central complex.

Background

Balanced mix design (BMD) is an enhanced approach to designing asphalt paving mixtures to achieve a satisfactory balance between rutting resistance and cracking resistance. Unlike the Superpave design approach, BMD focuses on optimizing mixture performance using simple mixture performance tests. BMD will provide a better way to assess mixture quality and is expected to open the door to utilizing more sustainable and innovative materials. Furthermore, implementation of simple mix performance tests as part of quality assurance will also ensure that the mixtures delivered to the project meet expected performance-related criteria.

In August 2018, NCAT completed National Cooperative Highway Research Program Project 20-07/Task 406 and developed a framework to address alternate approaches for implementation of BMD procedures that incorporate performance testing and criteria. Major outcomes of the project included survey responses from state highway agencies and asphalt contractors on their expectations for BMD, a literature review of current practices for mix design and performance testing, knowledge gaps and

research problem statements, as well as a preliminary draft AASHTO standard practice and specification for BMD. The draft standards have subsequently been balloted, revised, and approved as provisional standards that will be included in the 2020 edition of the AASHTO standards for materials and tests.

Workshop Overview

To advance toward implementation, the National Asphalt Pavement Association sponsored six regional BMD workshops conducted by NCAT Director Dr. Randy West and NCAT Assistant Research Professor Dr. Fan Yin. The workshops were designed for state highway agency materials engineers who are typically decision makers on mix design and acceptance specifications, asphalt industry managers responsible for asphalt mix designs and quality control testing, and other stakeholders interested in gaining an understanding of BMD. Topics covered in the workshops included:

- Superpave mix design limitations and refinements;
- BMD definition and approaches;
- Current mix design practices and modifications to improve performance;

- Asphalt mixture performance tests;
- Draft AASHTO standard practice and specification;
- Knowledge gaps and research needs;
- Implementation and partnerships between agencies and industry;
- Case studies and ongoing research; and
- Quality control and acceptance testing using performance tests.

The workshops required pre-registration on a first-come, first-served basis and were free to attend with the Federal Highway Administration providing travel funding to state agency personnel. The six workshop locations were selected primarily in states highly interested in implementing BMD and those that have already engaged in efforts to evaluate mixture performance tests for asphalt mix design (Figure 1).

Overall, the workshops were a great success with a total of 261 attendees consisting of approximately 44% from asphalt contractors, 35% from federal, state, and local highway agencies, and the remainder including participants from asphalt associations, materials suppliers, testing laboratories, consultants, and academic institutions. The workshops were

conducted in an interactive manner with question-and-answer sessions and open discussions throughout the schedule. Feedback from the workshop attendees was positive; the most popular topics were *Asphalt Mixture Performance Tests* and *Mix Design Modifications to Improve Performance Results*.

Workshop Highlights

Visit <https://aub.ie/bmdqa> for a list of questions and answers sparked by dynamic discussions during the workshops. A summary of highlights is provided below.

Many state DOTs expressed interest in implementing BMD because they have not seen much improvement in mix performance after implementing Superpave, with some poor mixes being designed and produced that still met all volumetric requirements. BMD was also seen as a better approach to evaluating and approving innovative products such as rejuvenators, special additives, and polymer modifications.

Contractors generally expressed a belief that performance test results would provide a better indication of mix quality than volumetric properties.

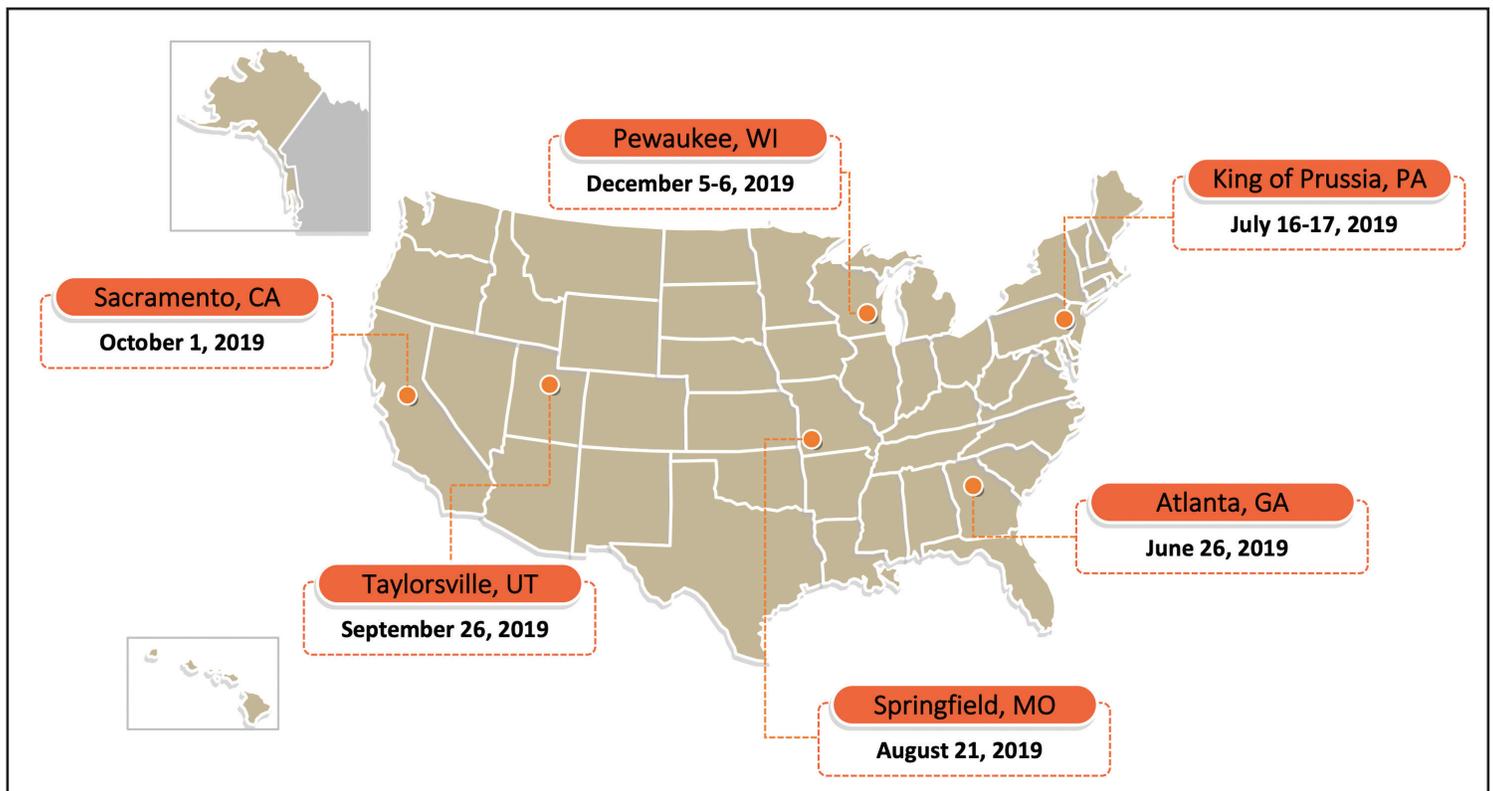


Figure 1. NCAT held Balanced Mix Design workshops at six locations across the country.

Contractors also noted that BMD should provide more flexibility during mix design and allow more opportunities to use innovative mix components to stay competitive in the low-bid environment.

Some of the biggest hurdles to BMD implementation are the selection of performance tests and criteria, performance testing during production (need test methods with quick turnaround on results to limit risks), and improvements in binder specification.

For state highway agencies interested in benchmarking current mix designs to establish performance criteria, NCAT recommends that priority should be given to mixes with known histories of field performance. The criteria should be set in a way to eliminate mixes that failed prematurely in the field. Meanwhile, contractors should conduct performance tests on their most common mixes to have an idea of how their mixes compare to others in the state.

A few state highway agencies have established requirements on the minimum asphalt binder content to mitigate “dry” mix issues. However, NCAT feels that this may not be a good practice because different aggregates will have different G_{sb} values and asphalt absorption values so the appropriate minimum asphalt content can be very different for different aggregates used within a state.

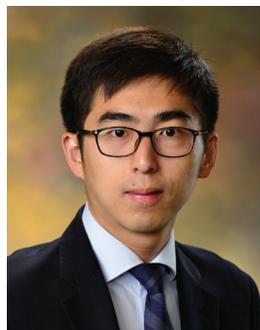
There are many different types of asphalt rejuvenators (including both bio-based and petroleum-based products) available on the market, but their ability to effectively improve cracking test results, especially after mix aging, varies significantly from product to product. Although numerous rejuvenators have shown promising laboratory results with mixtures containing high RAP contents and/or RAS, there have also been a few unsuccessful cases where the rejuvenated RAP/RAS mixtures failed prematurely in the field. Currently, there is no established laboratory procedure for the evaluation and approval of rejuvenators. NCAT is working on a research project for South Dakota DOT on this topic. Texas A&M University recently completed NCHRP Project 09-58, which provided guidelines on the use of recycling agents for asphalt mixtures with high RAP and RAS binder ratios. The project final report will be

published online soon as NCHRP Report 927. One factor that will impact the success or failure of a particular rejuvenator is its dosage rate. In theory, the dosage of rejuvenator should be determined based on the amount and properties of RAP and/or RAS binders. Blending charts (based on extracted binder blends) and mixture performance testing appear to be the two most promising approaches for determining the optimum dosage of rejuvenator.

Caution should be exercised when adding chemical additives (including rejuvenators, warm mix asphalt, and liquid anti-strip agents) into asphalt mixes containing polymer modified binders, as some of the additives may be not chemically compatible with the specific polymer used for asphalt modification. In such a case, the resultant mix will not perform as well as expected. This is another argument for the use of mixture performance tests in mix design and QA to assure that all of the individual components are compatible and can contribute to the performance of the mixture as expected.

It is NCAT’s opinion that the HWTT test temperature should be selected based on the climate of a project rather than the PG of the virgin binder used in the mix because the virgin binder grade would not account for the effects of recycled binders and other additives on the composite binder stiffness.

NCAT is working on a schedule for five additional one-day BMD workshops in 2020. Dates and locations are still to be determined. A national BMD conference is also being planned for March 31-April 1, 2021 in Nashville, TN. The 2020 workshops and conference are funded through NCHRP 20-44(19), Facilitating BMD Implementation. The project final report was recently published online as NCHRP Report 927.



**For more information, contact
Fan Yin at
f-yin@auburn.edu**

War Eagle Road



Tim Arnold, a 1994 Auburn engineering alumnus, had the idea to put America's newest musical road on Auburn's campus.

Drivers can now experience the first seven musical notes of Auburn's fight song, "War Eagle" as they head toward campus. The section of South Donahue Drive is dubbed "War Eagle Road" and is located on the northbound lane between Len Morrison Drive and West Sanford Avenue in Auburn, Alabama.

Rumble strips are typically placed at the edge of a road to alert drivers, and in most cases, are anything but pleasant to the ear—but with some reverse engineering, these vibrations can create distinctive frequencies that simulate musical notes and, in a sense, perform a musical composition.

"The concept is really kind of complex and simple at the same time," said Auburn alumnus Tim Arnold, who had the idea to put America's newest musical road on Auburn's campus.

In pure physics terms, sound is vibration going through matter, and a musical note is comprised of sound vibrations at a particular frequency. An 'A' note, for instance, vibrates at 440 hertz. Figure 1 is a

waveform of the first seven notes of the "War Eagle Fight Song", highlighting the iconic words and their corresponding notes. A complete mathematical model is used to determine the exact number of elements and necessary spacing on the roadway to make the right frequency of each note. An automobile driving across these physical disruptions in the road can then recreate a musical tune via the vibrations, which can be heard in (and around) the vehicle. Hearing the musical road is a bonus for traveling the roadway safely at the posted speed limit.

There are only a small number of musical roads around the world. The first was created as an art project in Denmark in 1995 and featured raised pavement markers to produce sound. Two other musical roads in America, created in 2008 and 2014, both used grooves in the pavement.

Arnold wanted to develop an improved method that would fit the project's requirements of strength and

durability while being safer, more durable, better sounding and, of course, non-destructive.

Working with NCAT, Arnold tested DOT-approved marking tape affixed to the pavement surface on an auxiliary road at the Test Track. After determining that trial tape could work in the field, it was tested under simulated traffic conditions. Accelerated laboratory friction testing equipment—developed at NCAT—was used to test two additional adhesive tapes. The lab results indicated that the adhesive tapes could last between 11 to 18 thousand revolutions in the NCAT Three Wheel Polishing Device, which is roughly equivalent to 33 to 54 thousand single tire passes.

While initial field tests of the material were conducted at South Donahue’s 45 mph speed limit, the speed limit was reduced to 35 mph when the road was changed from four lanes to two with a center turn lane and added bike lanes. Arnold recalculated the math based on the lower speed and tested new pieces.

With new calculations and testing complete, 36 pieces were produced and cut. Arnold and colleagues from Facilities Management and engineering helped adhere the pieces to a section of the northbound

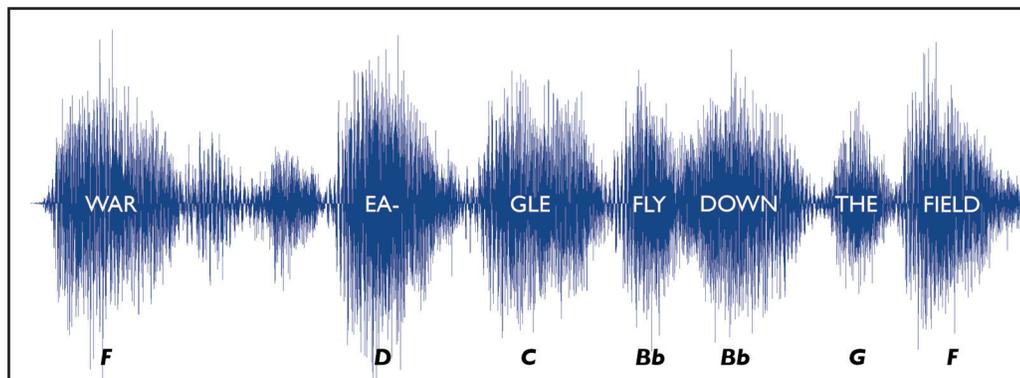


Figure 1. War Eagle fight song waveform.

lane on October 24, 2019. By utilizing materials intended to meet or surpass the current standards of road markers, costs are kept low and production and installation of the musical road is simple and repeatable.

Arnold already has a patent on this idea of creating a surface-applied material that is fabricated prior to road installation—locking in accuracy of the calculations and reducing the chance for error—and he is currently working to market this to other customers with additional potential applications.

“I’m hopeful that many other universities and towns large and small will be excited to celebrate their local culture with a musical road of their own,” he explained. “The driver-awareness and safety and qualities might also prove valuable to state departments of transportation, school or hospital zones, and construction crews who could benefit from the semi-permanent, non-destructive characteristics of the application.”

War Eagle Road is the first musical road with the surface application material, the first on a college campus and first with a fight song. Lancaster, California’s roadway plays “The William Tell Overture,” while the section of Route 66 in New Mexico plays “America the Beautiful.”



A trial pre-cut adhesive material was installed at the NCAT Test Track to reproduce the sound and frequencies of two musical notes.



For more information, contact
Fabricio Leiva at
leivafa@auburn.edu

NCAT Designated as NTPEP Testing Laboratory

The National Transportation Product Evaluation Program (NTPEP) is a national testing program hosted by the American Association of State Highway and Transportation Officials (AASHTO). This voluntary program was established to minimize the duplication of efforts among AASHTO member states by providing a process where manufacturers and suppliers submit products for independent testing. The results are then shared with AASHTO member states for their own use in product approval or product quality verification.

NTPEP is truly a win-win cooperative partnership between state DOTs and transportation industry participants. From a state’s perspective, NTPEP provides benefits including cost savings from reduced testing and auditing resources, improved product quality acceptance, reliable independent test results, and shared expertise and experience with other states. The benefits of NTPEP for suppliers are also substantial because it provides an opportunity to have their products exposed to all AASHTO member states at once, significantly shortening the product evaluation and approval process.

NTPEP currently has 24 product evaluation programs, with one being warm mix asphalt (WMA) additives and anti-strip additives (ASA). WMA and ASA are widely used asphalt technologies that provide environmental and performance benefits to asphalt paving mixtures. The objective of the WMA and ASA evaluation program is to compare mixes containing various WMA and/or ASA technologies to hot mix asphalt control mixes using the same asphalt binder and aggregate to determine relative performance.

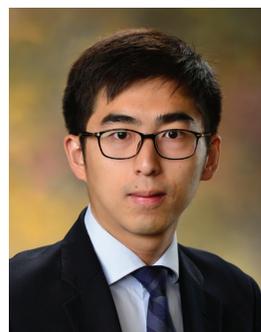
Table 1 shows a list of laboratory tests required for the evaluation of WMA and ASA technologies. The asphalt binder used in the program for laboratory-produced mixes is a neat PG 64-22 binder without modification. The WMA evaluation is based on a limestone mix design while the ASA evaluation requires two mix designs, one using a limestone aggregate and the other using a granite aggregate. A detailed work plan of the program can be found on the NTPEP website at <http://ntpep.org>.

Table 1. Laboratory tests for NTPEP evaluation of WMA and ASA technologies.

| Material | Laboratory Test | WMA | ASA |
|-----------------|---|-----|-----|
| Additive | Fourier Transform Infrared Spectroscopy | ✓ | ✓ |
| Asphalt binder | Performance Grade (AASHTO M 320) | ✓ | ✓ |
| | Multiple Stress Creep Recovery (AASHTO T 350) | ✓ | ✓ |
| Asphalt mixture | Mix Design Verification (AASHTO R 35) | ✓ | ✓ |
| | Compactability Test (AASHTO R 35) | ✓ | - |
| | Hamburg Wheel-Tracking Test (AASHTO T 324) | ✓ | ✓ |
| | Tensile Strength Ratio Test (AASHTO T 283) | ✓ | ✓ |
| | Ten Minute Boil Test (ASTM D 3625) | - | ✓ |

NCAT was selected as the testing laboratory for NTPEP’s WMA and ASA program in 2019. NCAT has completed the evaluation of eight products to date, including four WMA additives, three ASA additives, and one WMA plus ASA combined additive. Testing results of these products are available in the NTPEP DataMine online database at <https://data.ntpep.org/>.

NTPEP and NCAT have agreed to open three product submission cycles for 2020. The first cycle opened February 6, 2020 and closed February 28. Four WMA and ASA products were received. Testing at NCAT will commence in early April with an anticipated completion date of July 31, 2020. The other two submission cycles will open on June 1 and October 1, 2020.



For more information, contact Fan Yin at f-yin@auburn.edu

Auburn Students Receive Barton S. Mitchell Scholarships



Auburn University civil engineering students Connor Bailey, Madison Eason and David Allain (pictured left to right) were each presented with the Barton S. Mitchell Memorial Asphalt Industry Scholarship during NCAT's Applications Steering Committee Meeting on December 18.

This annual scholarship is aimed to support full time engineering students, especially those wishing to pursue a career in civil engineering. The scholarship was established in Bart's memory by the National Asphalt Pavement Association's Research and Educational Foundation, where he served as chairman of the board and was inducted into its Hall of Fame in 2010.

Specification Corner

Alabama DOT

Evotherm is now allowed as a WMA additive. RAP is no longer allowed in OGFC. We have added a specification for thin lift HMA. We have two pilot projects for performance based mix design on local (county) roads that will let in 2020 and the associated tests are Ideal-CT and High Temperature IDT.

Colorado DOT

CDOT is beginning to experiment with the Ideal-CT test to become familiar with it and see where our current mixes are for the CT Index.

Florida DOT

Roadway density is now 40% of a contractor's pay factor (up from 35%). The ultimate goal is 45%. 5% was removed from the asphalt binder pay factor.

Indiana DOT

INDOT has gone to full implementation of Superpave 5 in 2020. We target 5% air voids in the design and in the field. We've achieved this by reducing design gyrations to 50. For a "no cost" specification change, we are seeing an average density of 94.4% (previously 93.2%).

Massachusetts DOT

MassDOT has just released an updated version of our Standard Specifications at <https://www.mass.gov/lists/construction-specifications>. This update standardizes our use of the Superpave mix design methodology and quality assurance requirements for HMA pavement construction.

Minnesota DOT

In 2020, we will let four to five projects using Superpave 5 following the INDOT procedure.

Montana DOT

We have no major changes planned. Previously we had indicated a move towards AASHTO M 332 MSCR for our binder specification, however that hasn't happened. We are still interested in moving that way but haven't made much progress for various internal reasons.

Oklahoma DOT

We're adding ΔT_c (-6), maximum REOB 5%, and maximum PPA 0.5% to our Binder Specification and implementing balanced mix design with Hamburg and Ideal CT (min. 80). We are writing a new split sample/referee special provision. Currently, we are conducting trials of mixes with dry process crumb rubber, highly-modified binders, and aramid fibers. We are exploring alternates to T-283. 0.5% antistrip agent in all HMA/WMA is an option. We are considering the possibility of going to only liquid additives for WMA.

Ontario MOT

We've been testing recovered asphalt cement for acceptance on a trial basis on a few jobs since 2019 and using the HMA regression method to increase asphalt content on a trial basis. After a decade of pause, the ministry is revisiting hot in-place recycling with a long list of candidate jobs. We've been conducting mix performance tests on production HMA on trial basis for a few jobs this year for informational purposes.

Tennessee DOT

We are moving forward with phase 2 of our intelligent compaction specification, which adds data access for the inspector, weekly QC reporting, eliminates the separate pay item, and is planned to grow from roughly 35 projects the last couple years to approximately 50 this year.

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.

Do you use the spray paver with a 4.75 dense-graded mix? Do you have concerns with the water in the emulsion being trapped between the two lifts? Do you use the spray paver with larger NMAS mixes?

-Jerry Geib, John Garrity; Minnesota DOT

I am curious to know how other states have been affected by the changes to AASHTO T 324 *Standard Method of Test for Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures*. Research conducted for the purpose of better standardizing equipment requirements resulted in changes to the method that caused one widely used manufacturer's legacy equipment to be out of compliance. However, there is a long history of performance using that particular device. The changes to T 324 allow an agency to deviate from certain requirements and I'm curious if any have done so. We are trying to develop a comparative database to show that the legacy machine is still accurate, but are currently using another manufacturer for contract quality assurance (QA) and payment.
-Oak Metcalfe, Montana DOT

How many revisions do you allow on a job mix formula (JMF) before the mix needs to be redesigned?
-Tony Collins, North Carolina DOT

What states require the use of liquid antistrip agents in all mixes and what are the required dosage rates?
-Kevin Suitor, Oklahoma DOT

Asphalt Forum Responses

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

For those that use liquid antistrip agents, what method(s) do you allow to introduce them for asphalt mix during production (i.e. in-line at the mix plant, terminal blended, etc.)? What is the preferred method by contractors that use them and why? -Eric Biehl, Ohio DOT

Zane Hartzog, Alabama DOT

ALDOT allows blending of antistrip agents at the refinery or inline at the plant. I am told that contractors prefer inline blending for controlling cost of mixes that do not require antistrip agents. The ALDOT Standard Specification is Section 410.02 (c).

Michael C. Benson, Arkansas DOT

Blending is in-line at the mix plant or terminal blended. Our preferred method is terminal blended (producers do not have to modify plant).

Michael Stanford, Colorado DOT

CDOT does not allow liquid antistrips at this time.

David Howley, Connecticut DOT

ConnDOT has two producers that use WMA technology that doubles as an antistrip. One has it blended by the binder supplier, the other has purchased equipment to line feed at the mix plant.

Greg Sholar, Florida DOT

FDOT only allows terminal blending for liquid antistrip agents.

Mark Brum, Massachusetts DOT

We do not specify how antistrips are introduced. The majority of our producers choose to have antistrip terminally blended when it is required.

Jerry Geib, John Garrity; Minnesota DOT

MnDOT rarely uses an antistrip. If used, it would be liquid, terminal blend.

Tony Collins, North Carolina DOT

We have a few contractors that introduce the antistrip during production but most prefer terminal blended. I am not exactly sure why some prefer to introduce it during production.

Kevin Suitor, Oklahoma DOT

Either inline or terminal blended.

Seyed Tabib, Ontario MOT

In Ontario, the liquid antistripping additive is added in the asphalt cement terminal by the asphalt supplier (although we do not prohibit the in-line method at the plant).

Cliff Selkinghaus, South Carolina DOT

We only allow the antistrip to be terminally blended to ensure the dosage is correct, and we put this responsibility on the binder terminals to be sure they are compatible. Our LASA specification is SC-M-406, and our QPP and QPL is No. 104 on our website.

Matthew Chandler, Tennessee DOT

We allow in-line blended, terminal blended, or contractor tank dosing. I think the contractors prefer the in-line system if they have the equipment, as it gives the freedom to not have to use antistrips for private work if the client doesn't want it.

Enad Mahmoud, Texas DOT

Our TxDOT Standard Specification is Item 301: <https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/specs/2014/standard/s301.pdf>

With the increased use of RAP and growing RAP piles, consistency of these piles is important in good quality control and pavement uniformity. What are other DOTs requiring for quality control measures by contractors for testing the RAP piles? What tests are required and at what frequency? -Eric Biehl, Ohio DOT

Zane Hartzog, Alabama DOT

From ALDOT Testing Manual Section 372: gradation and AC% are checked using 10 samples in the first 10,000 tons then once for every 5,000 tons of RAP added to a stockpile.

Michael C. Benson, Arkansas DOT

RAP stockpiles are tested by the contractor for quality control (QC) purposes.

Michael Stanford, Colorado DOT

We test RAP at the same frequency that we do other aggregates. An AC extraction is performed by the contractor during the mix design, then we check the AC through burn offs throughout the project.

David Howley, Connecticut DOT

ConnDOT requires two moisture content tests per day. We adopted percent within limits (PWL) to determine pay factors on binder content in 2017. At that time, we removed the requirement of determining binder content of RAP daily. Producers seem to be determining binder content daily in order to maintain acceptable PWL results.

Greg Sholar, Florida DOT

FDOT requires that gradation and AC content be measured every 1000 tons and Gmm measured every 5000 tons. We have allowable tolerances for these properties. If results consistently fall outside of tolerance, then a mix design revision may need to be made.

Nathan Awwad, Indiana DOT

INDOT requires RAP to be processed so 100% passes the 2" sieve. For surface mixtures, we require the RAP to be a fine RAP with 100% passing the 3/8" sieve and 95 to 100% passing the No.4 sieve. We require producers to document their testing frequency in their QC plans. Tests shall include binder content, gradation, moisture content, CAA, and Gsb of the aggregate.

Mark Brum, Massachusetts DOT

Producers are required to test their RAP for binder content and gradation at a frequency spelled out in their QC plan. For mixes that use >25% RAP, the producer is required to perform full binder grade testing at least every 24,000 tons of mix produced in accordance with AASHTO M 323 Appendices X1 to X3 and show that the combined binder meets the specified binder grade for that mix type. We have an ongoing RAP research project looking at RAP pile consistency at different times and from plant to plant across the state. We expect that specification changes will be made once the project is completed.

Jerry Geib, John Garrity; Minnesota DOT

MnDOT does not test RAP piles.

Oak Metcalfe, Montana DOT

We recommend fractionating but have stopped short of requiring it.

Tony Collins, North Carolina DOT

NCDOT Standard Specification 7.5.8 QC Quartering (RAP or RAS Samples): the 25 lbs. RAP or RAS sample shall be quartered by the Contractor to obtain the appropriate size sample for binder content and gradation tests. Split portions of RAP or RAS samples will be retained for a period of seven calendar days, commencing the day the sample(s) is tested, or until disposal permission from QA personnel is given, whichever occurs first. QA personnel will also take verification RAP or RAS samples directly from the cold feed or stockpile. Calculations of the percent moisture in the aggregate, RAP, and RAS samples will be to the nearest 0.1 percent. To determine moisture content, it is necessary to secure a representative sample of the aggregate. The size of the sample taken is determined by the nominal maximum aggregate size of the material. Regardless of the size of the aggregate, the procedure for making a moisture determination is basically the same. Note: It is easier to obtain a representative sample from the production stream, such as from the conveyor belt, than from storage bins or stockpiles. When the sample is taken from the conveyor belt, it should be removed from the entire cross-section of the belt for a minimum of two (2) feet. NCDOT Standard Specification 7.9.1 General A.: washed gradations will be performed on the recovered aggregate from the mix and individual RAP samples.

Kevin Suitor, Oklahoma DOT

ODOT will soon be requiring isolated piles, extraction, gradation and PG grading of the RAP material.

Seyed Tabib, Ontario MOT

We do not currently allow RAP in surface mixes on Provincial highways. For binder mixes that include RAP, we test the extracted aggregate for acceptance. We are letting trial contracts where RAP is allowed in the surface course but then the recovered asphalt binder will be tested for acceptance. We may require mix performance testing on the production mix in the years to come. We are currently in the process of developing acceptance criteria for performance tests (i.e., SCB, Hamburg, DCT).

Cliff Selkinghaus, South Carolina DOT

We allow the contractors to replenish when they choose to fractionate their RAP. We require the contractors test for binder content and gradation at a minimum of 1 test per 1000 tons of processed-fractionated RAP.

Matthew Chandler, Tennessee DOT

We require gradation and AC content to be verified once per 1000 Tons of RAP utilized.

Enad Mahmoud, Texas DOT

To help mitigate this, we require fractionated RAP (over 3/8" or 1/2" sieve) at plant. Also, we have reduced the amount of RAP in surface mixtures since these layers are the most cracking susceptible.

How are other DOTs handling approval for mix designs using a specific RAP pile and then switching to another RAP pile? Is a new mix design submittal required? Is verification required to ensure that the RAP used is similar to the original pile? -Eric Biehl, Ohio DOT

Zane Hartzog, Alabama DOT

We do not approve mixes using specific RAP stockpiles.

Michael C. Benson, Arkansas DOT

We require initial approval of the mix design only.

Michael Stanford, Colorado DOT

A new RAP pile would require a new mix design. We test RAP throughout the project to ensure consistent gradation and AC content.

David Howley, Connecticut DOT

We do not monitor RAP piles.

Greg Sholar, Florida DOT

FDOT does not allow contractors to switch RAP piles for a mix design. It would require a different mix design.

Nathan Awwad, Indiana DOT

INDOT assigns RAP a Gsb of 2.640 by default on all designs. We have provisions for stockpile specific testing if the producer believes it is more than 2.660 or less than 2.620. Actual binder content is reported by the producer. INDOT does not determine unless we feel there is an issue.

Mark Brum, Massachusetts DOT

We currently do not approve mixes based on a specific RAP pile.

Jerry Geib, John Garrity; Minnesota DOT

Acceptance is based off of the mix design. No verification of RAP is required.

Oak Metcalfe, Montana DOT

We use what we refer to as volumetric targets in our QA program. A contractor normally gets a quantity of start up mix to work with to establish these targets at the beginning of a job. This mix is not subject to our full QA penalties/incentives. Once the targets are established, we measure deviation for QA. If the situation you describe takes place, there is no start up mix and targets must be set immediately, eliminating the contractor's ability to dial in their plant without suffering the full QA penalties.

Tony Collins, North Carolina DOT

Switching and verification of RAP is not being policed. We rarely require a new mix design when RAP piles change.

Seyed Tabib, Ontario MOT

We do not track the RAP piles; no procedure is in place. The end product should meet specifications at all times.

Cliff Selkinghaus, South Carolina DOT

We make sure the contractors keep up with the requirements for binder content and gradation testing when submitting new designs. Most do not have the space to place caps of individual stockpiles, so management is a nightmare unless you fractionate and don't allow them to replenish. We don't require the contractor to perform blending charts when running higher aged binder mixtures-no binder grade changes are required.

Matthew Chandler, Tennessee DOT

We consider RAP to be mix plant specific stockpile. If they fractionate, then they would become separate

stockpiles. A switch between a coarse and fine stockpile would require a change to the JMF.

Enad Mahmoud, Texas DOT

If they change RAP piles, then they should be performing another trial batch since gradations, aggregate, and binder is most likely different. We also have operational tolerances during production. So, if their densities, gradations, AC%, etc, fall outside tolerances, they will be penalized. It is in the contractor's best interest to disclose a change up front and ensure they can still meet the specification. I don't know if all contractors are being held accountable for this, however, we have large stockpiles of RAP in Texas, so I'm not sure how often they run out during production.

If you require prime coat, what material/type of emulsion do you allow to be used for prime coats?

-Matthew Chandler, Tennessee DOT

Zane Hartzog, Alabama DOT

ALDOT Standard Specifications for Highway Construction Section 401: emulsified asphalt: AE-P, CRS-1h, CMS-1hp, or NTSS-1HM; cutback asphalt: MC 30 or MC 70 for tight bases; MC 250, RC 70, or RC 250 for open bases. Emulsified Petroleum Resin: EPR.

Michael Stanford, Colorado DOT

CSS-1h & SS-1h. We have a specific requirement for our asphalt emulsion for prime coat. Saybolt: 20-150 seconds at 50°C per AASHTO T 59. % Residue: 65% minimum per AASHTO T 59. Oil distillate by volume %: 7% maximum per AASHTO T 59. Test on residue from distillation: solubility in Trichloroethylene %: 97.5 minimum per AASHTO T 44.

Greg Sholar, Florida DOT

FDOT has traditionally used AASHTO specified prime materials but lately several trackless tack suppliers have gone through the process of building test sections to get their trackless tack products approved as prime.

Mark Brum, Massachusetts DOT

We do not use prime coat.

Jerry Geib, John Garrity; Minnesota DOT

MnDOT does not prime.

Oak Metcalfe, Montana DOT

We have been allowing Magnesium Chloride as an "aggregate treatment" with varying results. We still allow a cutback emulsion (MC-70) but no one in our state uses or produces it.

Tony Collins, North Carolina DOT

NCDOT uses EA-P, CMS-PX, and CSS-1RP.

Eric Biehl, Ohio DOT

We require medium cure cutbacks (usually MC-30 or MC-70) for prime coats, but we haven't done many recently. For soil stabilization, rapid set emulsions (typically CRS-2) have been used and have appeared to work well.

Kevin Sutor, Oklahoma DOT

Several companies are producing a product specifically for asphalt prime coat.

Cliff Selkinghaus, South Carolina DOT

An emulsion called an EAP Special (Section 407.2.4 of the SCDOT standard) is commonly used in SC.

Enad Mahmoud, Texas DOT

TxDOT uses MC-30, AE-P, EAP&T, and PCE.



at AUBURN UNIVERSITY

1161 W. Samford Ave., Building 8
Auburn, AL 36849-0001

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Auburn, AL

National Center for Asphalt Technology
277 Technology Parkway, Auburn, AL 36830-5354
ncat.us | Phone: 334.844.6228 | Fax: 334.844.6248

Randy West, Director
Christine Hall, Editor, Writer
Courtney Jones, Writer

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