**AWARD NO. 693JJ32350026**

**Cooperative Agreement**
**DEVELOPMENT & DEPLOYMENT OF INNOVATIVE ASPHALT PAVEMENT TECHNOLOGIES (DDIAPT2)**

**Innovative Area: A. Materials**
**A.3: Other New & Innovative Materials as Agreed Upon**
**Statement of Work A.3.1: Use of High Polymer Modified Asphalt (HP) Binders and Mixtures Gap Analysis**

# Memorandum C
# Summary of Virtual Site Visit with the Oklahoma Department of Transportation

**Last Revised**
**11/07/2025**

**WRSC–M-25-1109**

| Use of High Polymer Modified Asphalt (HP) Binders and Mixtures Gap Analysis Virtual Site Visit | | | |
|---|---|---|---|
| State: | Oklahoma | District/Region: | Oklahoma DOT |
| Visit Made By: | Tim Aschenbrener (FHWA) and Jhony Habbouche (AI) | FHWA Division Office: | Waseem Fazal |
| Visit Type: | Asphalt Materials and Pavements | Visit Date: | September 13, 2024 |
| In Company With: David Vivanco (ODOT)<br>Ilker Boz (VTRC)<br>Elie Hajj (UNR) | | Federal Project Number(s): | Cooperative Agreement No. 693JJ32350026 |
| | | State Project Number(s): | N/A |
| Location: | Virtual site visit. | | |
| Description of work: | FHWA Development and Deployment of Innovative Asphalt Pavement Technologies (DDIAPT2), Innovation Area: A. Materials; A.3— Other New & Innovative Materials as Agreed Upon; Task A.3.2: Document Case Studies and Practices for Implementation of HP Binders and Mixtures | | |

☐ PODI

☒ Scheduled/Requested Visit? Activity requested by FHWA

☐ Unscheduled Review?

## DISCLAIMER

## Table of Contents

## List of Figures

No table of figures entries found.

# List of Tables

## Background

Polymer modification of asphalt binders is not a new concept and has become progressively more common over the past several decades. Over the past 50 years, asphalt binders have been modified with various components such as polymers, ground tire rubber, chemicals (e.g., acids), and recycled engine oils to enhance the performance of asphalt mixtures (Habbouche et al., 2020; Habbouche et al., 2021a). Several State departments of transportation (DOTs) have recognized the benefits of polymer-modified asphalt mixtures in resisting multiple modes of load- and climate-induced distress in flexible pavements (Habbouche et al., 2019). The most commonly used polymer-modified asphalt (PMA) binders (referred to herein as PMA binders) have rarely exceeded a polymer content of approximately 3.5% due to practical issues such as mixing, storage, and workability. However, a new polymer structure has allowed for its use in asphalt binders at much higher levels (approximately 7.5%), referred to herein as high polymer (HP) binders. These binders exhibit significantly greater elasticity, which may help mitigate some of the pavement failure modes that concern agencies (Bowers et al., 2017 and 2018).

HP binders offer additional advantages when used in asphalt mixtures subjected to heavy and slow-moving traffic. This application aligns with the Federal Highway Administration (FHWA)'s commitment to advancing resilient and high-performing infrastructure. The effectiveness of this technology was highlighted as a promising tool in the Every Day Counts (EDC)-6: Targeted Overlay Pavement Solutions (TOPS) program toolbox, featured alongside other asphalt overlay products (FHWA, 2021). Its inclusion aimed to enhance safety, improve performance, preserve investments, and realize cost savings. However, available information on mixtures utilizing HP binders (referred to herein as HP mixtures) is limited to specific field trials conducted in selected States. In addition, the use of HP binders has been limited to specific paving applications, primarily focusing on dense and open-graded mixtures, neglecting their use in gap-graded mixtures (e.g., stone matrix asphalt [SMA] mixtures). The development of specifications to characterize HP binders remains State-specific, lacking information related to defining and accepting such specialized binders. Information, lessons learned, and positive practices on the use of recycled materials and additives in HP mixtures are also limited. A recent study from Virginia Transportation Research Council (VTRC) indicated that 21 agencies have engaged in or constructed pilot projects involving HP mixtures (Habbouche et al., 2021b). As part of the FHWA EDC-6 TOPS Program, a case study highlighting Florida's experience with HP binders and mixtures provided helpful insights into research, construction considerations, and cost factors (Vargas et al., 2022). However, limited information on field performance was provided, and possibly missing practices from other States that use different raw materials and experience diverse climates.

The "Development and Deployment of Innovative Asphalt Pavement Technologies" program, referred to herein as the Asphalt | Innovate | Enlighten | Implement (AIEI) Program, is a five-year cooperative agreement with FHWA (9/23–9/28). The purpose of this program is to address the ongoing challenges faced by the transportation community to adopt new technologies and reduce the time to implement them in business practices, specifications, and construction methods relating design, production, testing, control, construction, and investigation of asphalt pavements. This project also supports the overall goals of advancing 21st-century solutions and improving performance and safety to keep America moving forward. Multiple efforts were undertaken as part of Year 1 of this effort. Among these, the effort entitled "Use of High Polymer Modified Asphalt (HP) Binders and Mixtures – Gap Analysis", was undertaken (SOW A.3.1).

## Objective

The overarching objective of this effort is to facilitate and conduct a comprehensive gap analysis on the use of HP binders and mixtures and identify critical limitations, gaps, and needs through Strengths-Weaknesses-Opportunities-Threats (S.W.O.T) analysis. In addition to addressing these limitations, the scope includes identifying and putting forth effective practices and lessons learned by DOTs. This will provide DOTs with valuable information for designing, constructing, and accepting HP binders and mixtures, and will complement the work completed under the FHWA EDC-6: TOPS program. To accomplish this objective, information was collected through virtual site visits and other means, as described below, with five key agencies. Oklahoma Department of Transportation (ODOT) graciously agreed to host a virtual site visit.

## Scope and Outcomes

The scope of each virtual site visit included:

- Watching a short pre-recorded kick-off webinar that expanded on the objectives of the effort.
- Completing a comprehensive data-gathering form developed by the Team, which consisted of 30 questions divided into nine modules.
- Attending a 2-hour meeting to discuss the agency's responses and address any additional follow-up questions or requests for information.

The outcomes of each virtual site visit included a summary of meeting notes, the recorded virtual site visit with the agency, and a brief summary memorandum to each FHWA Division Office and the agencies visited, outlining the observations and any recommendations identified.

This document serves as the brief summary memorandum on the observations and findings identified through the ODOT virtual site visit.

## Practice and Usage

ODOT currently specifies and permits the use of HP mixtures for standard maintenance and construction projects mainly in rich intermediate layers (referred to as RIL in ODOT specifications) (ODOT, 2019). HP binders are defined by ODOT as performance grade (PG) 88-28 or PG 76E-28 in accordance with AASHTO M 320 or M 332, respectively. According to ODOT, polymer-modified asphalt binders in general, including HP binders, are graded and tested using the Multiple Stress Creep Recovery (MSCR) test. For HP binders, the MSCR test, conducted in accordance with AASHTO T 350 at 76°C, specifies a maximum non-recoverable creep compliance ($J_{nr3.2}$) of 0.5 $kPa^{-1}$ and a minimum percent recovery ($R_{3.2}$) of 95% at 3.2 kPa. In addition, the flash point of HP binders is specified exceed 500°F (260°C). The residue, subjected to short-term aging via the rolling thin film oven (RTFO) and subsequently aged in the pressure aging vessel (PAV), is tested at 25°C using the Dynamic Shear Rheometer (DSR) in accordance with AASHTO T 315. A maximum $G^*\sin\delta$ value of 6,000 kPa at 25°C is specified in compliance with AASHTO M 332, where $G^*$ and $\delta$ represent the complex shear modulus and phase angle, respectively. Furthermore, HP binders have to demonstrate a separation of less than 10%. Separation test samples are prepared according to ASTM D5976, with results reported as the difference in $G^*$ between the top and bottom samples. No viscosity requirements are specified for HP binders. However, a maximum temperature of 350°F (177°C) is mandated for all PG-graded binders, including HP binders, except those used in Warm Mix Asphalt (WMA).

ODOT has been using HP mixtures for over five years, with initial applications dating back to 2009. The first use of HP mixtures was on the National Center for Asphalt Technology (NCAT) test track in an Oklahoma-sponsored section (N8) after an overlay mixture failed following 3.5 million equivalent single-axle loads (MESALs). In 2012, the same HP mixture was applied to a two-mile section of I-40. The HP mixture was noted for its low viscosity, making it workable and compactable in the field (Habbouche et al., 2019). The section (as typical) consisted of a 1.5-inch RIL using HP binder at the base, a 5.0-inch 19mm mix with HP binder as the intermediate layer, a 1.5-inch 9.5mm mix with HP binder as the binder course, and a 0.75-inch open-graded friction course (OGFC) with a PG76-28 (non-HP) binder as the surface layer.

ODOT has employed HP mixtures in structural overlays, as interlayers to mitigate reflective cracking, and in bottom layers to prevent bottom-up fatigue cracking. Over the past five years, ODOT has used HP mixtures for more than 110 miles of paving, averaging approximately 22 miles annually. During this period, around 307,887 tons of HP mixtures were placed on State projects, constituting roughly 1.6% of ODOT's total annual paving program by tonnage. The annual HP paving program has varied significantly in lane miles and tonnage over the last decade, depending on project size, the availability of alternative technologies, and program scope. Table 1 provides a detailed breakdown of the approximate annual tonnage of HP mixtures placed by ODOT over the past five years. The volume of HP mixtures used has fluctuated based on the specific demands of each year's program and the number of projects undertaken.

In terms of cost, Table 1 also summarizes the approximate price per ton of HP mixtures and the corresponding price difference compared to conventional PMA mixtures. HP mixtures resulted in a 21% to 31% cost increase over PMA mixtures. However, cost data can vary significantly depending on factors such as project type, tonnage, plant adjustments, project location, and the bidding process. Therefore, cost comparisons should be made cautiously, using projects of similar scope to properly assess price differentials.

Despite the higher initial costs, ODOT continues to use HP mixtures due to their performance benefits. In Oklahoma, HP mixtures are primarily used to mitigate bottom-up fatigue cracking, reflective cracking, and rutting. ODOT has also expressed interest in exploring the use of HP mixtures for designing thinner pavement sections.

**Table 1. ODOT Estimates of Annual Tonnage and Approximate Prices of HP Mixtures Used.**

| Year | Approximate quantity of HP mixtures placed (tons) | Approximate price for HP mixtures placed ($ per ton) | Approximate difference in price from conventional PMA mixtures ($ per ton) |
|---|---|---|---|
| 2019 | 30,649 | 100.87 | +17.71 |
| 2020 | 73,288 | 114.62 | +27.31 |
| 2021 | 52,981 | 111.88 | +26.14 |
| 2022 | 61,330 | 165.31 | +29.59 |
| 2023 | 89,639 | 156.83 | +30.66 |

ODOT = Oklahoma Department of Transportation; HP = high polymer-modified asphalt; PMA = conventional polymer-modified asphalt.

## Specifications

As previously mentioned, ODOT refers to HP binders as PG 88-28 or PG 76E-28, in accordance with AASHTO M 320 or M 332, respectively. These ODOT requirements include the MSCR test, conducted in accordance with AASHTO T 350 at 76°C, which mandates a maximum non-recoverable creep compliance ($J_{nr3.2}$) of 0.5 $kPa^{-1}$ and a minimum percent recovery ($R_{3.2}$) of 95% at 3.2 kPa. HP binders are used and specified in RILs by ODOT, with no reclaimed asphalt pavement (RAP) permitted in these mixtures (ODOT, 2019). The quality of supplied HP binders is generally verified to meet specification requirements at the terminal, typically once a month or whenever HP binder is being shipped, as well as at the plant. However, no information was provided regarding the frequency of quality checks conducted at the plant.

Regarding the acceptance process, ODOT does not have a distinct procedure for HP binders compared to conventional binders. During the certification process, ODOT collaborates with the binder supplier and asphalt contractor to ensure the binder is tested promptly so it can be shipped and used at the plant without delays. In terms of the current quality control program or practices specifically implemented for HP projects, no changes were reported for HP mixtures. For acceptance, ODOT continues to follow practices similar to those used for conventional mixtures.

## Mixture Design and Performance

ODOT uses the Superpave mix design methodology to design RILs, which specifies the use of HP binders. For RILs, the gradation from ODOT's S5 (9.5mm mix) is applied. The minimum asphalt content is specified at 5.5% of the total mix mass. The Superpave mix design is compacted to 50 gyrations, targeting a laboratory-molded density of 97.0% of the theoretical maximum specific gravity ($G_{mm}$), corresponding to 3.0% air voids. The mix design includes a voids in mineral aggregate (VMA) threshold of 15.5%, with a slightly reduced VMA threshold of 15.0% for field conditions. In addition, the mix design specifies voids filled with asphalt (VFA) within the range of 73% to 78%, with no specific VFA threshold range for field conditions.

During production, the layer has to achieve a density between 95.5% and 98.4%. The resistance to moisture damage is evaluated using the tensile strength ratio (TSR) test in accordance with AASHTO T 283. The minimum TSR value is 0.8 during the design stage and 0.75 for field conditions (ODOT, 2019). No RAP is permitted in RIL / HP mixtures in Oklahoma. During the mix design process, RIL HP mixtures are evaluated for rutting resistance using the Hamburg Wheel-Track Test in accordance with AASHTO T 324. The test is conducted at 50°C (122°F), and the mixture has to withstand at least 20,000 cycles before reaching a rut depth of 12.5 mm. Currently, no performance testing beyond volumetric properties, thickness, and density is specified for HP mixtures during production. No WMA additives are typically used for RIL HP mixtures. The use of liquid anti-strip is at the discretion of contractors and is generally determined by TSR test results. Table 2 summarizes the mix design and field properties of laboratory-molded specimens for HP RIL mixtures.

ODOT does not currently assign any additional structural credit for HP mixtures, and no changes to routine established practices have been reported regarding surface preparation or paving operations. In addition, no blistering has been observed or reported when using RIL HP mixtures.

**Table 2. Mix Design and Field Properties of Laboratory Molded Specimens for HP RIL Mixtures (ODOT, 2019).**

| Property | Properties | |
|---|---|---|
| | Mix Design | Field |
| Ndes, gyrations | 50 | 20 |
| Asphalt Binder Content, % by mix mass | ≥ 5.5 | ≥ 5.5 |
| NMAS, mm | 9.5 | 9.5 |
| Density, % of $G_{mm}$ | 97.0 | 95.5–98.4 |
| VMA, % | ≥ 15.5 | ≥ 15.0 |
| VFA, % | 73–79 | – |
| Lab Permeability, cm/s x $10^{-5}$ | ≤ 12.5 | – |
| TSR, Min. | 0.80 | 0.75 |
| Hamburg Rut Test, Min. No. of Cycles to 12.5 mm at 122°F | 20,000 | – |

–not applicable; HP = high-polymer modified; RIL = rich intermediate layer; Ndes = number of design gyrations; NMAS = nominal maximum aggregate size; $G_{mm}$ = theoretical maximum specific gravity of the mixture (rice); VMA = voids in mineral aggregates, determined based on the bulk specific gravity of the aggregates; VFA = voids filled with asphalt; Lab = laboratory; TSR = tensile strength ratio, Min. = minimum; No. = number.

## Restrictions and Limitations

ODOT reported no special practices or enforcement of specific safety or health restrictions when using HP binders in asphalt mixtures. In cases where specific practices are warranted, these are typically based on recommendations from binder suppliers and polymer manufacturers.

However, several factors have been identified as potential limitations to the broader use of HP binders, mixtures, and pavements in Oklahoma. These include high initial costs, as shown in Table 1 (the biggest limitation; selecting an RIL increases project costs); the lack of project selection criteria (ODOT is actively working on this aspect); and the absence of engineering design procedures (no additional performance testing or methodology to quantify the structural benefits of using RIL HP mixtures). Constructability has also been a significant concern for ODOT due to the limited time an RIL can remain open to early traffic before being overlaid, given the potential risk of rutting associated with the high binder content and finer mixture.

ODOT's experience with HP mixtures varied by location. For instance, Division 1 has used HP mixtures and RILs more frequently than other divisions, possibly due to a combination of the district Engineer's preference and contractors' experience. No challenges have been reported in acquiring contractors to bid on projects involving the production and placement of RIL HP mixtures.

## Research Projects

In terms of research efforts, ODOT has not commissioned any research contracts or studies to assess the use of HP mixtures within the State. However, ODOT reported that the sections constructed at the NCAT Test Track remained in place for another loading cycle.

At the NCAT Pavement Test Track in Opelika, Alabama, ODOT sponsored a test section aimed at developing a perpetual pavement for poor load-bearing native soils similar to those in Oklahoma. The section, designated as N8, experienced significant challenges during the 2006–2009 and 2009–2012 research cycles, ultimately failing twice due to severe rutting and cracking. These failures necessitated innovative rehabilitation approaches to ensure the continuation of testing and the collection of valuable data.

Initially, NCAT rehabilitated the section by milling out the top five inches and replacing it with the same mix design used in the original construction. However, the section failed again within just eight months into the 2009–2012 cycle. Given the urgency to repair the failed section without disrupting ongoing tests on adjacent sections, NCAT proposed using an HP binder and mixture—a material performing well in an adjacent test section, N7, sponsored by Kraton Polymers LLC.

The rehabilitation of Section N8 involved removing the top 5.75 inches of pavement, leaving approximately 4.25 inches of the underlying but failed pavement in place. The new design replicated the successful HP-based N7 structure, with some modifications to the aggregate size in the base course to address the specific challenges of subgrade rutting and cracking. HP binder, containing 7.5% Kraton D0243 modified styrene-butadiene-styrene (SBS) polymer, was utilized in a 5.75-inch pavement structure comprising three asphalt concrete layers. The binder was mixed with heated aggregate to produce the hot mix asphalt on-site.

Reconstruction began in August 2010, with East Alabama Paving leading the efforts. The project incorporated advanced paving and compaction techniques, including the use of material transfer vehicles and multi-stage roller compaction, to ensure proper installation. Upon completion, test trucks resumed traffic on the section, and NCAT's embedded instruments restarted data collection to monitor pavement performance.

The rehabilitated N8 section represented a critical learning opportunity for NCAT, ODOT, and Kraton Polymers. By integrating HP technology into the design, the effort provided insights into balancing rut resistance and crack mitigation on weak subgrade soils. Although challenges persisted, the work contributed to Oklahoma's pursuit of a durable and cost-effective perpetual pavement solution while advancing NCAT's mission to develop high-performing pavements.

### Cost and Benefits

ODOT reported no information on life cycle costs or benefit-cost ratios for HP mixtures. As previously mentioned, HP mixtures were associated with a 21% to 31% cost increase compared to conventional PMA mixtures.

### Implementation Plan

The implementation of HP binders and mixtures in Oklahoma did not originate from a formal plan but rather emerged as a necessity. Early failures at the NCAT test track provided critical insights, which were later applied to a problematic section of I-40. This practical approach formed the foundation for the adoption of HP binders in RIL mixtures in the State. Pilot projects incorporating HP mixtures were constructed, but these were not accompanied by control test sections specifically built for comparison with conventional asphalt mixtures. Instead, existing older conventional pavements were connected to these projects, allowing indirect performance observations.

Initially, the use of HP mixtures was not permitted statewide. ODOT preferred to evaluate the performance of the I-40 section and ongoing research on Section N8 at the NCAT test track before expanding their use. Once the success of Section N8 and the I-40 implementation was recognized, other Districts within the State began adopting HP mixtures for their projects.

Currently, ODOT has fully implemented the use of HP mixtures, though this process evolved gradually as confidence in their performance grew. This success demonstrates the value of field performance evaluation and iterative adoption as critical elements of implementing advanced asphalt technologies like HP mixtures.

## Additional Information

The use of HP binders and mixtures in Oklahoma has provided several lessons learned, highlighted challenges, revealed positive practices, and exposed certain gaps. One significant lesson learned pertains to the use of RIL with HP binders on existing concrete pavements. If the RIL is placed on top of concrete and subsequently covered with another lift on the same day without allowing adequate cooling time, such as overnight, the heat retained in the RIL can act as an insulator. This can lead to severe issues, including buckling or blowouts of the underlying concrete. Allowing the mat to cool properly before placing the next lift is therefore critical.

A notable challenge encountered has been the limited shelf life of HP binders, which is typically around 2–3 days. Beyond this period, issues such as plugged pipes and filters on asphalt binder lines, cooling of the HP binder leading to pumping difficulties, and settlement at the bottom of asphalt binder storage tanks have been observed. These issues can disrupt production and create logistical hurdles for asphalt producers.

To address this challenge, a positive practice has emerged among producers. Many ensure that only enough HP binder is delivered for the day's production, reducing the likelihood of prolonged storage and associated complications. This proactive approach has proven effective in mitigating the risks related to HP binder's short shelf life.

Despite these advances, certain gaps remain. For example, there is limited exploration into how to extend HP binder's shelf life or optimize storage conditions to address its inherent challenges.

## Acknowledgement

The team greatly appreciates the time, effort, and information provided by ODOT staff. This concludes the summary of the virtual visit with ODOT.

## References

American Association of State Highway and Transportation Officials. *AASHTO M 320-23, Standard Specification for Performance-Graded Asphalt Binder*, AASHTO, Washington, DC, 2023.

American Association of State Highway and Transportation Officials. *AASHTO M 332-23, Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recover (MSCR) Test*, AASHTO, Washington, DC, 2023.

American Association of State Highway and Transportation Officials. *AASHTO T 283-22, Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage*, AASHTO, Washington, DC, 2022.

American Association of State Highway and Transportation Officials. *AASHTO T 324-23, Standard Method of Test for Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures*, AASHTO, Washington, DC, 2023.

American Association of State Highway and Transportation Officials. *AASHTO T 350-22, Standard Method of Test for Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dyamic Shear Rheometer (DSR)*, AASHTO, Washington, DC, 2023.

ASTM Standard D5976, "Standard Specification for Type I Polymer Modified Asphalt Cement for Use in Pavement Construction," ASTM International, West Conshohocken, PA, *withdrawn in 2005*.

Bowers, B.F., Diefenderfer, B.K., and Diefenderfer, S.D. *Evaluation of Highly Polymer Modified Asphalt Mixtures: Phase I*. VTRC 18-R14. Virginia Transportation Research Council, Charlottesville, 2018.

Bowers, B.F., Diefenderfer, S.D., and Diefenderfer, B.K. Laboratory Evaluation of a PlantProduced High Polymer–Content Asphalt Mixture. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2631, 2017, pp. 144-152.

Federal Highway Administration (FHWA). Targeted Overlay Pavement Solutions (TOPS) – Highly Modified Asphalt. FHWA-HIF-21-003, Federal Highway Administration, Washington, DC, 2021.

Habbouche, J., Boz, I., and Diefenderfer, B.K. *Laboratory and Field Performance Evaluation of Pavement Sections with High Polymer-Modified Asphalt Overlays*. VTRC 21-R16, Virginia Transportation Research Council, Charlottesville, 2021a.

Habbouche, J., Boz, I., Diefenderfer, B.K., Smith, B.C., and Adel, S.H. State of the Practice for High Polymer-Modified Asphalt Binders and Mixtures. *Transportation Research Record: Journal of the Transportation Research Board*, Volume 2675 (7), 2021b, pp. 235-247.

Habbouche, J., Hajj, E.Y., and Sebaaly, P.E. *Structural Coefficient of High Polymer Modified Asphalt Mixes*. WRSC-UNR-FDOT-BE321-DEL6. Florida Department of Transportation, Tallahassee, FL, 2019.

Habbouche, J., Hajj, E.Y., Sebaaly, P.E., and Piratheepan, M. A Critical Review of High Polymer-Modified Asphalt Binders and Mixtures. *International Journal of Pavement Engineering*, Vol. 21, 2020, pp. 686-702.

Oklahoma Department of Transportation. Standard Specifications for Highway Construction. Oklahoma City, OK, 2019.

Vargas-Nordcbeck, A. and Musselman, J. A. *Highly Modified Asphalt Florida Case Study*, Final Report to U.S. Department of Transportation, FHWA-HIF-22-044, Federal Highway Administration, Washington, DC, 2022.

MEMO

WRSC-M-25-1109

November 2025

ASPHALT | INNOVATE | ENLIGHTEN | IMPLEMENT

**Connect with us on our LinkedIn page to keep current with all team member events and program progress!**

For other cooperative agreements materials, information, or technical assistance, please visit:
https://www.fhwa.dot.gov/pavement/asphalt/coopmaterials/
https://www.unr.edu/wrsc/tools/asphalt

This material is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange under agreement number 693JJ32350026 Development and Deployment of Innovative Asphalt Pavement Technologies. The U.S. Government assumes no liability for the use of the information in the non-FHWA-branded documents.