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 E
Summary of Virtual Site Visit with the New Jersey Department of Transportation

Last Revised
11/07/2025

WRSC–M-25-1111

Use of High Polymer Modified Asphalt (HP) Binders and Mixtures Gap Analysis Virtual Site Visit

State:	New Jersey	District/Region:	New Jersey DOT
Visit Made By:	Tim Aschenbrener (FHWA) and Jhony Habbouche (AI)	FHWA Division Office:	Paul Cardie
Visit Type:	Asphalt Materials and Pavements	Visit Date:	October 1, 2024
In Company With: Caroline Gobrial, Edward Inman, Mark Gillece, Robert Blight, and William Kettleson (NJDOT) Dave Johnson (AI) 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?

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. The New Jersey Department of Transportation (NJDOT) 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 NJDOT virtual site visit.

Practice and Usage

NJDOT currently specifies and permits the use of HP binders and mixtures for standard maintenance and construction projects, primarily for bridge deck waterproofing surface courses (BDWSC) and ultra-high-performance thin overlays (UHPTO). Additionally, HP binders with performance grades (PG) 88-22FR (FR denotes Fuel Resistant) and PG 94-22 binders are being explored in chip seal applications. Traditional chip seals, commonly used across the country, have not performed well in New Jersey due to early stone loss and displacement over time. Consequently, NJDOT is exploring binders that can be applied hot to better anchor aggregate while competing with high-friction surface course treatments. This initiative aims to develop preservation solutions that also enhance skid resistance.

The binders used in chip seal applications (i.e., PG 88-22FR and PG 94-22) are still graded in accordance with AAHSTO M 320, even though NJDOT has transitioned to AASHTO M 332 for modified asphalt binders. NJDOT has expressed challenges with short-term aging of such binders since they do not fully coat the interior of the rolling thin film oven (RTFO) jars. To address this, NJDOT is drafting new specifications for testing PG 94-22 binders.

Despite over 18 years of HP mixture use, NJDOT acknowledges the absence of a formal definition for HP binders. Current specifications are based on AASHTO M 332, including compliance with the elastic response requirement of AASHTO R 92. Polymer loading has not been standardized.

In collaboration with the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University, NJDOT has sought to address pavement durability and cracking issues by reverse-engineering specialty asphalt mixtures. This approach focuses on increasing competition and reducing costs by moving away from proprietary mixtures. Reverse engineering has involved evaluating satisfactory performance using performance tests, including the Asphalt Pavement Analyzer (APA), Overlay Tester (OT), Flexural Bending Fatigue (FBF), and more recently the Indirect Tensile Cracking Test (IDEAL-CT) and Indirect Tensile Test at High Temperature (IDT-HT). This effort aligns with NJDOT's objective to link asphalt mixture design with pavement structural design and performance, ensuring longer-lasting pavements (Hajj and Aschenbrener, 2021).

NJDOT has increasingly prioritized performance testing for asphalt mixtures, with less emphasis on binder testing. The focus is shifting toward testing asphalt mixture properties to ensure compliance with performance criteria. Binder tests primarily confirm the true grade based on submitted certificates of analysis. However, NJDOT is exploring advancements in binder testing to provide more comprehensive data for characterizing HP binders.

In 2006, Rutgers University initiated asphalt mixture performance testing to reverse-engineer a proprietary BDWSC mixture designed for application on the steel panels of the George Washington Bridge. This work was conducted for the Port Authority of New York and New Jersey. The BDWSC mixture was developed by analyzing the performance of asphalt mixtures treated with Rosphalt, a concentrated thermoplastic virgin polymer additive. By 2007, a performance-based specification (PBS) for the BDWSC was adapted to meet the specific requirements of NJDOT for use on concrete bridge decks. This modified specification incorporated key performance criteria, including limits on rut depth using the APA and fatigue performance as measured by FBF cycles to failure. Although there are no restrictions on which binder can be used, experience has shown that HP binders are necessary to meet the pre-established performance specifications for these mixtures.

In 2006, a specification for high-performance thin overlays (HPTO) was introduced for pavement preservation and resurfacing applications. This specification was modeled after a 6.3 mm fine mixture used by the New York State Department of Transportation (NYSDOT), with the APA test included to address concerns about potential rutting. Initially, the HPTO specification did not incorporate a cracking performance test. However, the OT was later added in response to feedback and observations from field performance. For HPTO, NJDOT previously utilized PG 64E-22 binders but has since increased performance requirements to incorporate more polymer modification. This adjustment aims to support heavier-traffic roadways and composite pavement preservation projects by developing thin layers that effectively resist reflective cracking, commonly referred to as UHPTO. For these applications, a PG 76E-28 binder or better performance binder grade, specifically formulated to meet the mixture performance criteria, have to conform to AASHTO M 332, including compliance with the elastic response requirement of AASHTO R 92 (NJOT, 2019). NJDOT began using UHPTO on a pilot project in 2024.

Over the past six years, NJDOT has placed approximately 4.8 million tons of HP mixtures on State projects as shown in Table 1, with annual paving programs varying based on project size, available technologies, and program scope. On average, HP mixtures cost $158.27 per ton on average, roughly 32% higher than conventional PMA mixtures ($119.86). Despite higher initial costs, NJDOT continues to use HP mixtures for their superior performance benefits, including mitigating fatigue and reflective cracking, reducing rutting, and enabling thinner asphalt layers.

NJDOT has consistently utilized HP binders and mixtures across various applications and has never discontinued their use in assigned pavement projects. These materials remain a cornerstone of NJDOT's efforts to improve pavement performance and durability while advancing innovative engineering solutions.

Table 1. NJDOT 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	363,663	--	--
2020	818,417	--	--
2021	443,302	--	--
2022	116,874	--	--
2023	1,262,031	--	--

NJDOT = New Jersey Department of Transportation; HP = high polymer-modified asphalt; PMA = conventional polymer-modified asphalt; -- = not available.

Specifications

As previously mentioned, NJDOT specifies and permits the use of HP binders for BDWSC and UHPTO mixtures. However, the selection of the binder is primarily driven by the performance requirements of the asphalt mixtures being produced. In addition, trial maintenance projects have included performance grades like PG 88-22FR and PG 94-22 in chip seals, though these are still graded in accordance with AASHTO M 320 despite NJDOT's shift to AASHTO M 332 for modified binders. Challenges with short-term aging, particularly for stiffer grades like PG 88-22, have led NJDOT to start working on new specifications for PG 94-22 testing.

The quality of supplied binders is generally verified to meet specification requirements at the terminal, typically during production and shipping, accompanied by a certificate of analysis. Additionally, regular sampling and testing of binders are conducted at the plant. Field verification is performed only for binders used in chip seal applications, such as PG 88-22FR and PG 94-22.

Regarding the acceptance process, NJDOT does not have separate procedures for HP binders compared to conventional binders. All binders, regardless of storage time, have to meet PG testing. However, for specific applications like BDWSC and UHPTO, additional performance testing requirements are in place to evaluate mixture resistance to rutting and cracking. In terms of the current quality control program or practices specifically implemented for HP projects, no changes were reported for HP mixtures. NJDOT continues to follow acceptance practices similar to those used for conventional mixtures. However, changes are currently being drafted for the acceptance program, specifically for the PG 94-22 chip seal special provisions. These updates aim to address the unique characteristics of these polymer-modified asphalt binders and ensure consistent performance. Acceptance testing for PG 94-22 binders focuses on quality assurance and includes testing such as rotational viscosity, dynamic shear rheometer (DSR), flash point, penetration, softening point, elastic recovery, creep stiffness and others.

Mixture Design and Performance

NJDOT employs a structured approach to the design and performance evaluation of BDWSC and UHPTO mixtures. For mix design, volumetric properties are prioritized initially. Once the mixture meets volumetric requirements, it undergoes performance testing to ensure compliance with specifications. BDWSC and UHPTO are designed using 50 gyrations, targeting lower air voids, higher voids in mineral aggregates (VMA), and specific performance testing requirements as shown in Table 2. Reclaimed asphalt pavement (RAP) materials are not permitted in these mixtures. For UHPTO, the design air void content is set at 3.5%, with production air void tolerances ranging from 2.5% to 4.5%. Conversely, chip seal applications, such as those incorporating PG 88-22FR and PG 94-22 binders, do not require formal mix design procedures.

Table 2. Mix Design and Control Properties for BDWSC and UHPTO Mixtures (NJDOT, 2019).

Property	BDWSC		UHPTO	
	Design	Control	Design	Control
Volumetric Properties				
Ndes, gyrations	50		50	
Asphalt Binder Content, % by mix mass	≥ 7.0		≥ 7.0	
NMAS, mm	9.5 or 12.5		4.75 or 9.5	
Density, % of G_{mm}	99.0	98.0–100.0	96.5	95.5–97.5
VMA, %	≥ 18.0		≥ 18.0	
VFA, %	90–100		–	
Dust-to-Binder Ratio	0.3–0.9		0.6–1.2	0.6–1.3
Draindown, % (AASHTO T 305)	≤ 0.1 %		≤ 0.1 %	≤ 0.1 %
Performance Properties ***(Air Void Content of Specimen is maximum 3.0% for BDWSC and 5.0±0.5% for UHPTO)***				
APA Rut Depth at 64°C and after 8,000 loading cycles, mm (AASHTO T 340)	≤ 3.0 mm		≤ 3.0 mm	
Flexural Fatigue Life at 15°C / 10 Hz / 1,500 microstrain, cycles	≥ 100,000		–	
Overlay tester at 25°C and a joint opening of 0.635 mm, cycles (NJDOT B-10)	–		≥ 2,500	

–not applicable; BDWSC = bridge deck waterproofing surface courses; UHPTO = ultra-high performance thin overlay; 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; VFA = voids filled with asphalt; APA = asphalt pavement analyzer.

NJDOT does not treat BDWSC and UHPTO mixtures differently from conventional mixtures in terms of structural credits. Surface preparation for these mixtures generally aligns with traditional methods, though exceptions exist, such as the use of precoated aggregates in PG 88-22FR chip seal applications to ensure proper adhesion.

For performance evaluation, NJDOT incorporates FBF testing (AASHTO T 321) for assessing crack initiation and propagation. BDWSC mixtures particularly benefit from this approach due to the focus on crack initiation resistance. Ovelay performance (i.e., for UHPTO mixtures), on the other hand, emphasizes crack propagation. Recommendations from experts at Rutgers University have suggested shortening production-phase fatigue testing to streamline operations. NJDOT has observed that failures primarily occur during the design and test strip phases; once production begins, issues tend to diminish as contractors refine their processes.

NJDOT has also integrated additional performance measures such as the IDEAL-CT (ASTM D8225, 2019) and High Temperature IDT tests. These quicker tests reduce the frequency of failures before more rigorous evaluations like the APA and OT are conducted.

HP mixtures present unique challenges during compaction, particularly for thin lifts (i.e., UHPTO) that cool rapidly. Contractors have to act swiftly to compact these lifts effectively to avoid heat loss, which can lead to compaction difficulties. Weather conditions also play a significant role; wet paving seasons have resulted in blistering issues when contractors paved over wet surfaces, contrary to specifications. Over-compaction is another challenge, as it can reduce friction and drive finer gradations in UHPTO mixtures. Friction testing, macrotexture evaluation, and rideability assessments are conducted for all projects except chip seals, where NJDOT is developing new specifications for enhanced performance.

NJDOT has also explored hot-applied chip seals using PG 94-22 binders to address the limitations of standard emulsion chip seals, particularly for New Jersey's demanding road conditions. These chip seals feature smaller aggregate sizes (¼" minus) for better retention and reduced aggregate rolling. Performance testing for these binders includes assessments via DSR, Rotational Viscosity, Penetration, and Softening Point. NJDOT has waived maximum viscosity limits to accommodate pumping requirements.

The motivation for adopting HP chip seals lies in their superior performance under New Jersey's challenging conditions, including high traffic loads, limited road closure hours, and variable climate. These efforts aim to develop a specification that ensures durability, friction, and overall road safety, addressing issues such as aggregate retention and skid resistance while optimizing mixture performance.

Restrictions and Limitations

NDOT reported no special practices or enforcement of specific safety or health restrictions when using HP binders in asphalt mixtures (e.g., BDWSC and UHPTO 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 New Jersey. One of the main challenges is the high initial cost associated with these mixtures, which remains a significant barrier to their widespread adoption (refer to Table 1). Another limitation stems from the lack of experience within industry regarding the use of HP mixtures. Many agencies have limited knowledge and experience with HP binders, which adds a layer of uncertainty when considering their adoption. This is compounded by the fact that local contractors are often not equipped to handle HP mixtures, with only a small number of contractors capable of working with high PG binders. The limited number of contractors available to perform these specialized tasks reduces competition and availability, potentially driving up costs and delaying project timelines.

Previous unsuccessful experiences with HP mixtures have also contributed to hesitancy in their use. For instance, a bridge deck mix, which initially met all design specifications and performance requirements, experienced severe rutting within two days of application. Upon investigation, it was discovered that the contractor had failed to switch to the specified binder, which led to the premature failure of the mixture. This failure highlights the importance of stringent quality control and adherence to the correct binder specifications, as well as the need for contractors to be well-trained in handling HP mixtures. Resistance from competing industries has also played a role in limiting the use of HP mixtures. The paving industry has shown resistance to adopting pavement preservation methods such as chip seals, which are seen as alternatives to traditional paving approaches. This reluctance to change within the industry further slows the adoption of new materials and methods, despite their potential benefits.

Research Projects

Currently, NJDOT does not have any completed or ongoing laboratory or field research projects specifically related to HP mixtures beyond those conducted in New York City. However, there are a few pilot projects underway involving high polymer-modified asphalt technologies. One such project involves UHPTO, which is currently in its pilot phase on I-295. Another project is being conducted on Route 42, which also involves the use of HP mixtures. Additionally, a relatively new chip seal product utilizing PG 94-22 binder is being piloted this year. Both the UHPTO and chip seal projects are research-driven, exploring the potential benefits and performance of these HP binder and mixtures in real-world applications.

Cost and Benefits

NJDOT reported no information on life cycle costs or benefit-cost ratios for HP mixtures. As previously mentioned, HP mixtures were associated with about a 32% cost increase compared to conventional PMA mixtures.

Implementation Plan

The use of HP binders and mixtures in the State has not been guided by a specific implementation plan. The primary intent behind promoting these specialty mixtures (BDWSC and UHPTO) was to achieve improved performance rather than focusing solely on high polymer-modified technologies. Pilot projects featuring HP binders and mixtures, such as PG 88-22 chip seal and UHPTO, have been constructed, but no control sections featuring conventional asphalt mixtures were included in these projects. HP mixtures were not allowed Statewide from the outset, and the implementation has been gradual. Over a span of more than five years, the number of projects per year has varied. While NJDOT has fully implemented HP mixtures for BDWSC, it continues to explore the potential benefits and performance of HP binders in UHPTO mixtures and chip seals.

The successful implementation of HP mixtures has been guided by reliance on researchers and reviewing the experiences of other State DOTs. Notably, New York's work with UHPTO has served as an influential example. While specific tips or lessons learned from the implementation process are not available, the approach has focused on leveraging research insights and learning from the broader DOT community.

Additional Information

The use of HP binders and mixtures in the State has led to several lessons learned, challenges, positive practices, and gaps that highlight both the potential and limitations of these materials. One lesson learned is the need for new acceptance testing and criteria. With HP binders having a higher viscosity than conventional binders, the traditional testing methods may not adequately capture their performance characteristics. This necessitates the development of new or modified testing approaches that can accurately evaluate these materials' performance.

A significant challenge encountered is the industry's resistance to adopting pavement preservation techniques, such as those involving HP binders. There is also the added complexity of handling binders with higher viscosity, which can complicate production and application processes. These issues can create barriers to broader acceptance and use within the State.

However, there have been positive practices that have emerged to address some of these challenges. The proactive approach of using only the necessary amount of binder for daily production helps mitigate potential logistical complications related to binder handling. Additionally, efforts to make asphalt mixtures more homogeneous by blending different sources of RAP have shown promise, as producers are reporting no significant issues with the mixtures' performance. This practice reduces the risk of inconsistencies in the material, improving the overall quality of the final product.

Despite these advances, gaps remain in the current use of HP binders. One key gap is the limited understanding of how traditional PG binder tests can be supplemented for HP binders. There is a need for further research to refine testing methodologies to ensure they accurately capture the performance characteristics of these materials.

Acknowledgement

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

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 R 92-22, Standard Practice for evaluating the Elastic Behavior of Asphalt Binders Using the Multiple Stress Creep Recovery (MSCR) Test*, AASHTO, Washington, DC, 2022.

American Association of State Highway and Transportation Officials. *AASHTO T 321-22, Standard Method of Test for Determining the fatigue Life of Compacted Asphalt Mixtures Subjected to Repeated Flexural B ending*, AASHTO, Washington, DC, 2022.

American Association of State Highway and Transportation Officials. *AASHTO T 340-23, Standard Method of Test for Determining Rutting Susceptibility of Asphalt Mixtures Using the Asphalt Pavement Analyzer (APA)*, AASHTO, Washington, DC, 2023.

ASTM Standard D8225-19, "Standard Test Method for Determination of Cracking Tolerance Index of Asphalt Mixture using the Indirect tensile Cracking Test at Intermediate Temperature," ASTM International, West Conshohocken, PA, 2019.

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.

Hajj, E.Y., and Aschenbrener, T.B. *Case Studies on the Implementation of Balanced Mix Design and Performance tests for Asphalt Mixtures: New Jersey Department of Transportation (NJDOT)*. WRSC-TR-21-06. Pavement Engineering and Science, University of Nevada, Reno, NV, 2021.

New Jersey Department of Transportation. *Standard Specifications for Road and Bridge Construction*. Trenton, NJ, 2019.

Vargas-Nordbeck, 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.

ASPHALT | INNOVATE | ENLIGHTEN | IMPLEMENT

MEMO

WRSC-M-25-1111

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.