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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 A
Summary of Virtual Site Visit with the Ohio Department of Transportation

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Use of High Polymer Modified Asphalt (HP) Binders and Mixtures Gap Analysis Virtual Site Visit			
State:	Ohio	District/Region:	Ohio DOT
Visit Made By:	Tim Aschenbrener (FHWA) and Jhony Habbouche (AI)	FHWA Division Office:	Robert Hinman
Visit Type:	Asphalt Materials and Pavements	Visit Date:	August 26, 2024
In Company With: Craig Landefeld, Eric Biehl, Mason Williams (OH DOT) Dave Johnson (AI) Stacey Diefenderfer (VTRC) 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

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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 properties 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 with five key agencies. The Ohio Department of Transportation (OH DOT) 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 OH DOT virtual site visit.

Practice and Usage

Ohio DOT currently specifies and allows the use of HP mixtures on standard maintenance and construction projects. The primary application of these HP binders in asphalt mixtures is for bridge waterproofing and in high-stress locations with stability concerns.

Ohio DOT defines HP binders as a pre-blended binder that meets a performance grade (PG) of 88-22M, in accordance with their specifications (OH DOT, 2024) and AASHTO M 320. The pre-blended binder is produced by modifying a base neat asphalt binder of at least a -22 grade (or even a -28 grade) with polymers such as styrene-butadiene (SB), styrene-butadiene-styrene (SBS), or Elvaloy. There are no restrictions on the polymer content in this modification. The binder is graded using actual pass temperatures without conducting a direct tension test. It has to also meet the requirement of exhibiting no more than a 0.75% mass change when tested using the rolling thin film oven (RTFO). In addition, the RTFO residue has to exhibit an elastic recovery of at least 90%, as specified by a modified version of AASHTO T 301. The binder has to display a separation of no more than 10% when conditioned according to ASTM D7173 and when assessing the softening point difference between the top and bottom of the tube, as per AASHTO T 53. While OH DOT imposes these requirements, there are currently no specifications for phase angle, toughness, tenacity, elongation, or ductility of HP binders. The requirement of a maximum rotational viscosity of 3.0 Pa.s for the PG 88-22M may be waived (upper limit increased to 10 Pa.s) at the discretion of the OH DOT if the supplier certifies that the binder can be adequately pumped, mixed, and compacted at or below the specified temperature (maximum 350°F [177°C]) according to OH DOT construction and material specifications (OH DOT, 2024). At the time of shipment, the rotational viscosity of the PG 88-22M binder has to not exceed 10.0 Pa.s when tested with a #27 spindle.

OH DOT has been using HP mixtures for about ten years, with initial applications dating back to 2014. The first projects involved placing HP mixtures at two intersections and on several bridge decks. The first large-scale project occurred in 2017, with approximately 100,000 tons of HP mixtures produced and placed. HP mixtures have since been specified for a variety of applications, including high-stress locations such as intersections, bridge decks, and other areas requiring enhanced durability. Over the past ten years, OH DOT's annual HP paving program has varied significantly in lane miles, depending on project size, the availability of alternative technologies, and the scope of the program. Table 1 provides a detailed breakdown of the approximate annual tonnage of HP mixtures placed by OH DOT. The volume of HP mixtures used fluctuates based on the specific demands of each year's program and the number of projects undertaken.

In terms of cost, HP mixtures typically resulted in a 7% to 10% increase on large tonnage resurfacing projects compared to conventional polymer-modified mixtures. For smaller projects, the cost increase ranged from 10% to 20%, largely due to plant modifications and smaller production volumes. It is important to note that cost data can vary drastically depending on factors such as project type, tonnage, and plant adjustments. As a result, comparisons are to be made with caution to ensure that projects of similar scope are used to assess the price differential properly. Despite the higher costs, OH DOT continues to use HP mixtures due to their performance benefits, particularly in high-stress environments.

Table 1. OH DOT Estimates of Annual Tonnage of HP Mixtures Used.

Year	Quantity of HP Mixtures Places (tons)	Description
2014	3,326	2 projects
2015	6,762	9 projects including 8 bridges
2016	3,738	7 projects including 5 bridges
2017	113,802	10 projects including 7 bridges. 2 of the 10 projects had significant high tonnage of HP mixtures
2019	19,545	13 projects including 9 bridges and full depth ramp construction
2020	3,147	9 projects including 8 bridges
2021	5,006	10 projects including 9 bridges
2022	46,864	10 projects including 7 Bridges
2023	103,055	4 projects including 1 bridge
2024	4,014*	3 projects including 1 bridge

OH DOT = Ohio Department of Transportation; HP = high polymer-modified asphalt; * = as of August 28, 2024.

OH DOT uses HP mixtures primarily to prevent rutting, for research purposes, and in applications such as bridge deck waterproofing and high-stress locations (as mentioned previously). OH DOT is also exploring other potential uses, including full-depth pavement for cost efficiency, perpetual pavements, and thinner overlays for areas with low overhead clearance. OH DOT has reported that it has never discontinued the use of HP mixtures at any time.

Specifications

As mentioned previously, OH DOT specifies the use of HP mixtures primarily for bridge deck waterproofing and high-stress areas where a documented issue exists at a specific location. The quality of the supplied HP binders is generally verified to meet specification requirements both at the terminal and the plant. At the terminal, random visits are conducted throughout the year, during which samples are taken, and full testing is performed. At the plant, testing is conducted to verify the binder grade. However, there is a tendency to perform full testing at the plant due to the limited number of visits to the terminal during actual HP binder production and the likelihood of HP binders being made and shipped within a short timeframe. This practice is similar to how other binders are handled on State projects.

Regarding the acceptance process, OH DOT does not have a distinct procedure for HP binders compared to conventional binders. During the certification process, OH DOT collaborates with the binder supplier and asphalt contractor to ensure the asphalt binder is tested as quickly as possible so the product can be shipped to and used at the plant.

In terms of the current quality control program or practices specifically implemented for HP projects, no changes were reported for non-bridge deck mixtures. However, for bridge deck mixtures, the design air voids are set at 1.5%, which is also typically used as the production target.

For acceptance, OH DOT maintains practices similar to those used for conventional mixtures. Daily HP binder samples are usually pulled at the plant if a monitor is available on-site.

Mixture Design and Performance

Superpave mix design methodology is typically used for HP mixtures in high-traffic areas (e.g., interstates, freeways), except for base mixtures, where the 6-inch Marshall mix design is adopted. Bridge deck waterproofing mixes have additional criteria in accordance with supplemental specification (SS) 856 as shown in Table 2 (OH DOT, 2023). Moreover, reclaimed asphalt pavement (RAP) is not permitted in these types of mixtures.

Table 2. Mid Design Criteria for Bridge Deck Waterproofing Asphalt Surface Course (as per Supplemental Specifications 856).

JMF Criteria	Specification
Total Modified Binder, %, min	7.25
Gyrations, Ndes/Nmax	50/75
Air Voids, %	1.5
VMA, %, min	15.5
Permeability, ft./day, max[1]	2.8×10^{-4}
Rutting, mm, max[2]	4.0
Flexural Beam Fatigue, cycles, min[3]	100,000

Ndes = number of design gyrations; Nmax = maximum number of gyrations; VMA = voids in mineral aggregates.
[1] permeability test is performed in accordance with ASTM D5084 on samples with 2.0 +/- 0.5% air voids.
[2] Rutting test is performed in accordance with AASHTO T 340 using an asphalt pavement analyzer (APA) at 147°F (64°C) on average of three gyratory specimens compacted to 4.0 +/-0.1 % air voids.
[3] Flexural beam fatigue testing is required only for mixtures placed on steel deck bridges. This test is performed in accordance with AASHTO T 321 at 1500 microstrains, 10 Hz, on an average of two samples with 4.0 +/- 1.0% air voids.

OH DOT currently does not assign any additional structural credit for HP mixtures (similar to conventional material). However, OH DOT expressed interest in exploring how the properties of HP binders and mixtures could be leveraged in structural designs through a research project titled "A Field Evaluation of the Perpetual Pavement Concept Confirmation." More details about this project are provided in the "Research Projects" section.

OH DOT reported no differences in surface preparation when placing HP asphalt mixtures compared to traditional mixtures. It confirmed following the same procedures for all mix types, including HP mixtures. For composite pavements, OH DOT does not anticipate using HP materials as a substitute for joint repairs. Instead, OH DOT encourages all districts to assess load transfer efficiency (LTE) prior to resurfacing.

In terms of compaction, no changes were reported regarding the type of rollers or the number of passes typically used. Coring for density assessment is still required. An interesting observation was noted regarding the base mix, which needed minimal compaction effort, while the HP mixture took longer to cool down.

OH DOT reported no immediate need for additional performance metrics but emphasized the importance of evaluating the cost/benefit of using HP mixtures. This evaluation could include constructing test and control sections to determine whether the performance improvements justify the additional costs. Although this was addressed in the Perpetual Pavement project, long-term performance data remain limited.

OH DOT also expressed interest in exploring the use of HP mixtures as interlayers. In addition, OH DOT is actively investigating the use of Balanced Mix Design (BMD). However, currently, OH DOT has no plans to explore increasing the RAP content in asphalt mixtures when using HP binders.

Restrictions and Limitations

OH DOT reported no special practices or enforcement of specific safety or health restrictions when using HP binders in asphalt mixtures. However, several factors were identified as potential limitations to the broader use of HP binders, mixtures, and pavements in Ohio. These include high costs, and the lack of established engineering design procedures tailored for HP materials.

One major concern highlighted by OH DOT is whether Ohio's asphalt terminals could sustain the supply demands if larger volumes of HP mixtures were required. This concern stemmed from a survey conducted by OH DOT regarding the production and supply of PG 88-22M binders. The survey comprised eight questions, including whether respondents were binder suppliers, their willingness to produce PG 88-22M per OH DOT requirements if production tonnage increased, and their maximum annual production capacity. OH DOT also inquired about limiting factors for producing HP binders. All respondents willing to produce PG 88-22M agreed that tank storage capacity and shelf life were primary concerns. In addition, binder suppliers expressed divided opinions regarding whether PG 88-22M is more frequently specified compared to conventional grades such as PG 70-22M or PG 76-22M. Suppliers highlighted the risks associated with producing specialty polymer-modified binders, emphasizing that:

- Binder suppliers can only make a limited number of specialty production runs.
- Supply and demand play a critical role in managing the risks of producing specialty binders.
- A lack of demand makes it challenging to commit to long-term production of binders like PG 88-22M.

To address these risks, suppliers suggested that DOTs reduce the number of binder grades specified for asphalt mixtures. A simplified range of products would allow suppliers to focus on producing valuable, consistent, and cost-effective materials. Suppliers also noted that having too many grades can increase the need for blending or in-line blending, raising both risks and costs for suppliers and buyers (DOTs).

Additionally, it was noted that the SBS polymer required for PG 88-22M differs from that used for grades like PG 70-22M or PG 76-22M. Availability of the necessary SBS material could limit production capacity for PG 88-22M and potentially affect the production of other binder grades. Some suppliers mentioned attempts to derive PG 70-22M or PG 76-22M binders from PG 88-22M through rack blending to mitigate supply challenges.

OH DOT also requested additional feedback from suppliers regarding considerations for using more PG 88-22M mixtures. Key insights provided include:

- Life Cycle Cost Analysis (LCCA): Suppliers emphasized that while higher SBS levels may extend the lifespan of asphalt mixtures, the improvement in durability may only result in a modest payback period of a few months. Despite this, longer-lasting mixes provide significant cost savings for taxpayers, particularly for low-traffic pavements where enhanced durability reduces maintenance needs.
- Durability Factors: Suppliers noted that while asphalt binder properties influence long-term pavement performance, other factors such as mix design quality, proper construction practices, and quality control often play a more critical role. Research from National Center for Asphalt Technology (NCAT) and National Asphalt Pavement Association (NAPA) indicates that binders with higher performance grades may not always yield a proportional benefit in terms of durability and value. For example, some of the best-performing roads use well-designed mixes with everyday binders like PG 64-22.

Suppliers also expressed concerns about increased costs, storage times, and material testing challenges associated with HP binders:

- Testing Variability: Advanced testing protocols such as RTFO (Rolling Thin Film Oven) and subsequent evaluations can produce highly variable results, complicating quality assurance.
- Specification Revisions: Suppliers suggested simplifying specifications by focusing on original binder parameters (e.g., Original DSR at 88°C, elastic recovery, and viscosity) to reduce variability and streamline testing.
- Production Costs: Higher production costs, increased viscosity, and energy-intensive processes in milling and handling HP mixtures further contribute to the economic challenges of widespread adoption.

In summary, while HP binders offer potential performance benefits, careful evaluation of cost, supply chain limitations, and practical implementation challenges are needed. Suppliers recommended balancing technical specifications with market demands to ensure long-term viability and affordability.

Research Projects

Two research projects involving the use of HP binders and mixtures are highlighted. The first project, titled "Implementation and Thickness Optimization of Perpetual Pavements in Ohio," was conducted by Ohio University and published in June 2015 (Sargand et al., 2015). The objective of this study was to evaluate the performance of perpetual pavement structures constructed by OH DOT. Three test sections on U.S. Route 23 in Delaware, Ohio (referred to as DEL-23) were built with asphalt layer thicknesses of 11 inches (28 cm), 13 inches (33 cm), and 15 inches (38 cm). Each section was instrumented to measure strains in the Fatigue Resistant Layer (FRL) and base layers, along with deflections, temperatures, and subgrade pressures. Controlled Vehicle Load (CVL) testing conducted during summer revealed that the 13-inch section on stabilized subgrade and the 15-inch section on compacted subgrade satisfied perpetual pavement criteria, while the 11-inch section on stabilized subgrade did not. Computer simulations using PerRoad supported these results but suggested that the 11-inch section might still meet perpetual pavement criteria under ideal conditions.

To further explore these findings, additional test pavements were constructed at the Accelerated Pavement Load Facility (APLF). These sections were thinner, ranging from 8 to 11 inches, and incorporated HP binders and mixtures. The 11-inch section served as a control, utilizing conventional asphalt in the base and HP mixtures in the upper layers. Unlike DEL-23, no FRL was included. Results showed that both the 10-inch (25 cm) and 11-inch (28 cm) HP sections met perpetual pavement criteria, even when heated to 100°F (37.8°C). After 10,000 passes of a 9,000 lb (40 kN) load at 5 mph (8 km/h), surface rutting was measured and found to be well below OH DOT's threshold for "low rutting" (0.125 inches or 0.32 cm). Curve extrapolation further indicated that HP surfaces would outperform conventional or Warm Mix Asphalt (WMA) surfaces in rutting resistance over time. However, it is important to note that these findings were based on controlled testing conditions, and field performance may vary. The fatigue endurance limits of the DEL-23 and APLF sections were determined using laboratory-measured parameters and calculations based on the National Cooperative Highway Research Program (NCHRP) Project 9-44A method and Mechanistic-Empirical Pavement Design Guide (MEPDG) guidelines. These limits showed strong alignment with the observed field performance.

In addition, ten high-performing asphalt pavements identified in a previous forensic study (Sargand and Edwards, 2010) were re-evaluated to determine their potential as perpetual pavements. Field investigations included distress surveys, falling weight deflectometer (FWD) testing, dynamic cone penetrometer (DCP) measurements, and Portable Seismic Property Analyzer (PSPA) evaluations. Strains at the bottom of the asphalt layers were backcalculated using the elastic modulus program Evercalc, and the results were verified through finite element modeling with Abaqus. Of the ten pavements assessed, seven met conservative perpetual pavement strain criteria, while one could be upgraded to meet the criteria with the addition of an asphalt overlay. The remaining two pavements clearly failed to meet perpetual pavement standards. Lastly, the study briefly reported on the status of earlier perpetual pavement designs constructed in Stark County (STA-77) and Wayne County (WAY-30). These findings contribute to a broader understanding of perpetual pavement performance and highlight the importance of material selection, thickness design, and controlled testing conditions in achieving long-lasting, durable pavements.

The second project, entitled "A Field Evaluation of the Perpetual Pavement Concept", (submitted in October 2024) focused on the innovative concept of Perpetual Pavement, a design approach aimed at extending pavement lifespan by utilizing multiple layers of materials to mitigate key distresses such as fatigue cracking and rutting (Khoury et al., 2024). Ohio's implementation of perpetual pavements since 2003 was highlighted, with a pivotal 2015 study demonstrating that asphalt pavements exceeding 13 inches in thickness on a stabilized base met perpetual pavement criteria. This project focuses on the use of HP mixtures to construct and instrument the first in-service perpetual pavement in Ohio, located on Wayne Route 83 in Wooster. This project features seven test sections with advanced instrumentation, including strain gauges, pressure cells, and temperature sensors, to comprehensively monitor pavement behavior under real-world conditions. Field testing using controlled truck loads and laboratory evaluations—such as dynamic modulus, Hamburg wheel tracking, and IDEAL-CT—revealed that HP mixtures offer superior resistance to rutting and cracking. Structural analysis indicated that while HP materials increase costs by 10-20%, they have the potential to extend service life by approximately 25%, or 12-15 additional years. Recommendations emerging from this effort include long-term performance monitoring, expanded cost-benefit analyses, and further investigation of material interactions, particularly with high RAP content. Action items include developing a dedicated perpetual pavement design guide for OH DOT and providing necessary training to optimize the use of HP mixtures in perpetual pavement applications.

Cost and Benefits

OH DOT confirmed that data on life cycle cost analysis (LCCA) for HP mixtures is available through the most recent research effort conducted by Ohio University, as detailed in the previous section. As noted, while HP materials typically increase costs by 10-20%, they have the potential to extend pavement service life by approximately 25% (~3 years), This would increase average performance from approximately 12 years to approaximately15 years. Furthermore, OH DOT has been actively compiling data on the price and tonnage of HP mixtures over the years to reassess benefit-cost ratios and evaluate the overall effectiveness of HP mixtures. This ongoing effort remains a priority for OH DOT and will be revisited in the future as additional data becomes available.

Implementation Plan

The implementation of HP binders and mixtures in Ohio began with an initial plan to introduce HP materials as a competitive alternative to Rosphalt® for bridge deck waterproofing in order to achieve better pricing. Around the same time, several high-stress projects were initiated, which aligned with the rollout of the bridge deck waterproofing specifications. Pilot projects featuring HP mixtures were constructed, including control sections with conventional asphalt mixtures to enable performance comparisons. Notably, the current perpetual pavement project includes instrumented test and control sections with various pavement configurations, as documented in the October 2024 report. While HP mixtures were not allowed statewide from the outset, their use has been implemented successfully for bridge deck waterproofing and high-stress locations, though work remains ongoing to expand their application into other areas. Key lessons learned during implementation included the importance of balancing material costs against the quantities specified, as well as anticipating potential plant upgrades necessary for producing HP mixtures.

Additional Information

The use of HP binders and mixtures in Ohio has provided several lessons learned, identified challenges, highlighted positive practices, and revealed existing gaps. A key lesson learned is that HP mixtures do not require special construction practices for handling, placement, or compaction, as they can be treated similarly to conventional PMA mixtures and placed at typical temperatures. However, attention has to be given to certifying or approving suppliers of the binder, particularly when agency results are required during production, as the timely turnaround of samples can become critical. One notable challenge is the characterization of HP mixtures' ability to withstand additional loading without inducing cracking. Positive practices include the ability of HP mixtures to address instability issues in high-stress locations while demonstrating superior performance in rutting, cracking, and mass loss testing compared to standard mixtures. Despite these successes, gaps remain in fully integrating HP binders and mixtures properties into structural pavement design methods, establishing long-term performance evaluations, and refining mix design processes to align with BMD approaches, including appropriate test temperatures and performance criteria chosen by the agency.

Acknowledgement

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

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