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Balanced Mix Design (BMD)–Challenges & Opportunities

Insights from Regional Peer-to-Peer Exchanges

Derek Nener-Plante

Principal, DNP Infrastructure LLC



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Our Visit Today



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Where

- Market Motivators

Why

- The Transition to BMD

What

- Key Challenges

Now

- Opportunities and Actionable Steps

Thoughts

- Conversation



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TECH BRIEF

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AUTHORS

Elie Y. Hajj (ORCID: 0000-0001-8568-6360), *University of Nevada, Reno*

Timothy B. Aschenbrener (ORCID: 0000-0001-7253-5504), and Derek Nener-Plante (ORCID: 0000-0001-7642-326X), *Federal Highway Administration*

Fan Yin (ORCID 0000-0003-4238-9387), and Thomas P. Harman (ORCID: 0009-0000-3741-8417), *National Center for Asphalt Technology*

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APRIL 2025

Balanced Mix Design of Asphalt Mixtures: Challenges & Opportunities

This Technical Brief summarizes key challenges State Departments of Transportation (DOTs) face in adopting Balanced Mix Design (BMD) that are categorized into three focus areas: management (M), technical (T), or overlapping technical-managerial (TM). It also highlights associated opportunities and actionable steps to support effective BMD implementation.

Introduction

As part of the Federal Highway Administration (FHWA) *Development and Deployment of Innovative Asphalt Pavement Technologies* program, six regional peer-to-peer exchanges were conducted (Figure 1).⁽¹⁻⁶⁾ These exchanges facilitated discussions on implementation challenges, emerging themes, and key takeaways related to BMD. The peer-to-peer exchanges covered Southeast, North Central, Northeast, Rocky Mountain West, Midwest, and Mid-Atlantic regions. In addition to these efforts, separate virtual exchanges with Mega-States were held approximately every six months to address unique challenges and share progress specific to larger state agencies. Key objectives included:

- Providing information and effective practices for State DOTs starting or considering the transition to BMD.
- Sharing lessons learned from State DOTs that have pioneered BMD implementation.
- Discussing operational changes and challenges associated with BMD implementation.



Figure 1. U.S. map of BMD peer-to-peer exchange participants.



Where



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Why is the performance of asphalt pavements important?



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- Our Roadways are a major asset in terms of replacement cost.
- Pavements are the biggest part of construction spending in the Federal-Aid system:
 - ~60%+ of all federal-aid
 - \$30+ billion in 2024



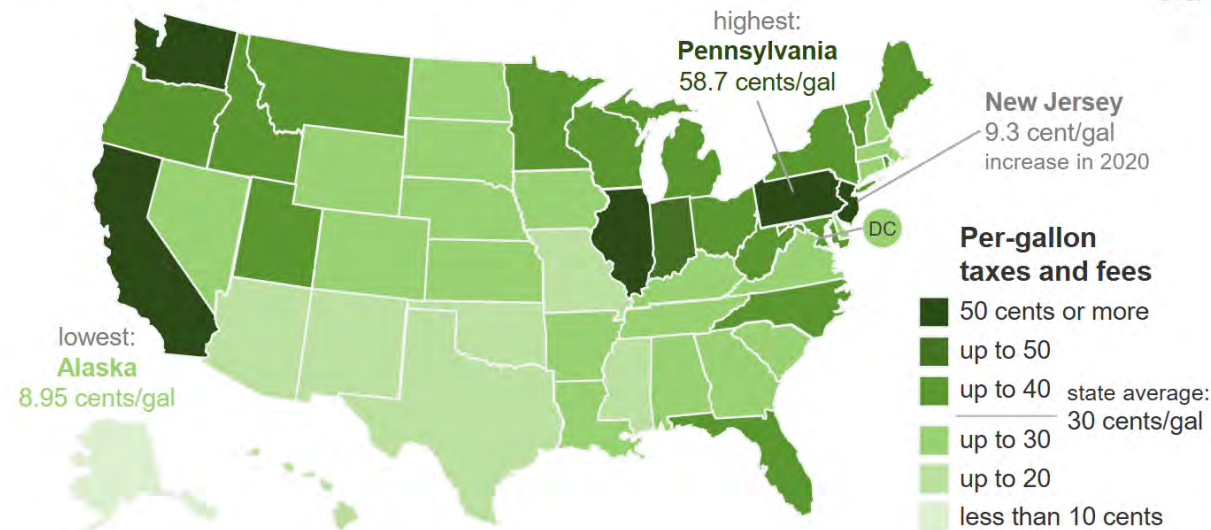


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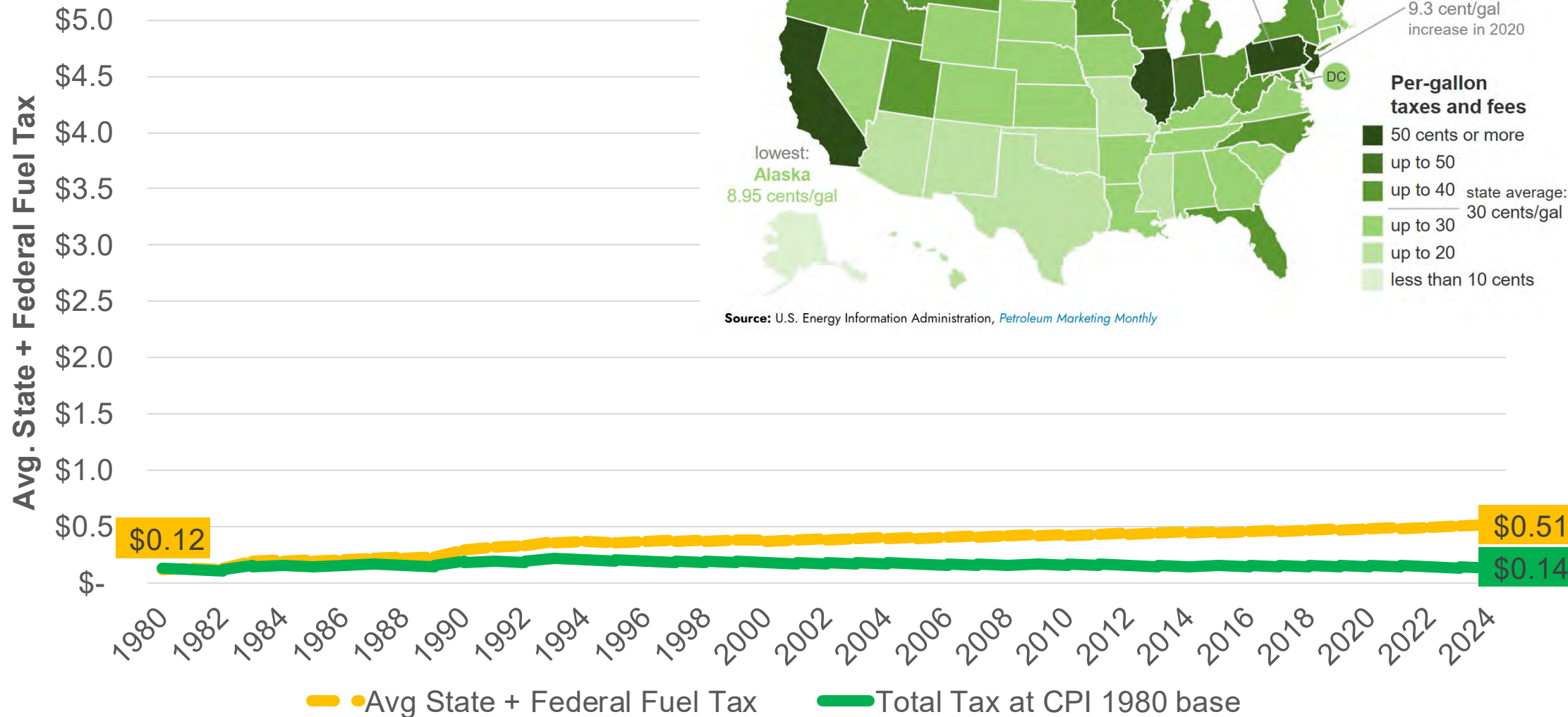
APRIL 1, 2021

State gasoline taxes average about 30 cents per gallon

State taxes and fees on motor gasoline (as of Jan 1, 2021)

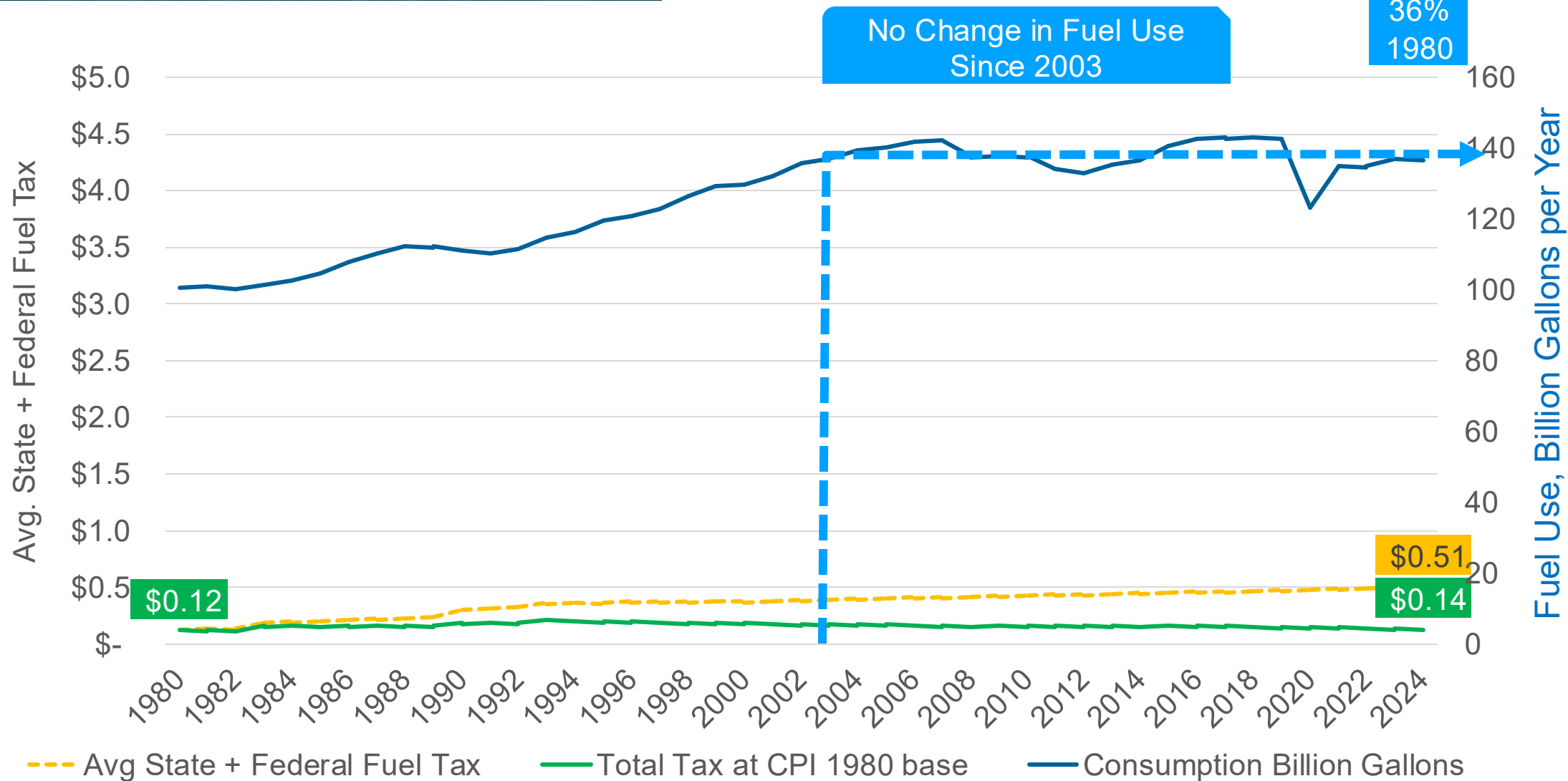


Source: U.S. Energy Information Administration, *Petroleum Marketing Monthly*



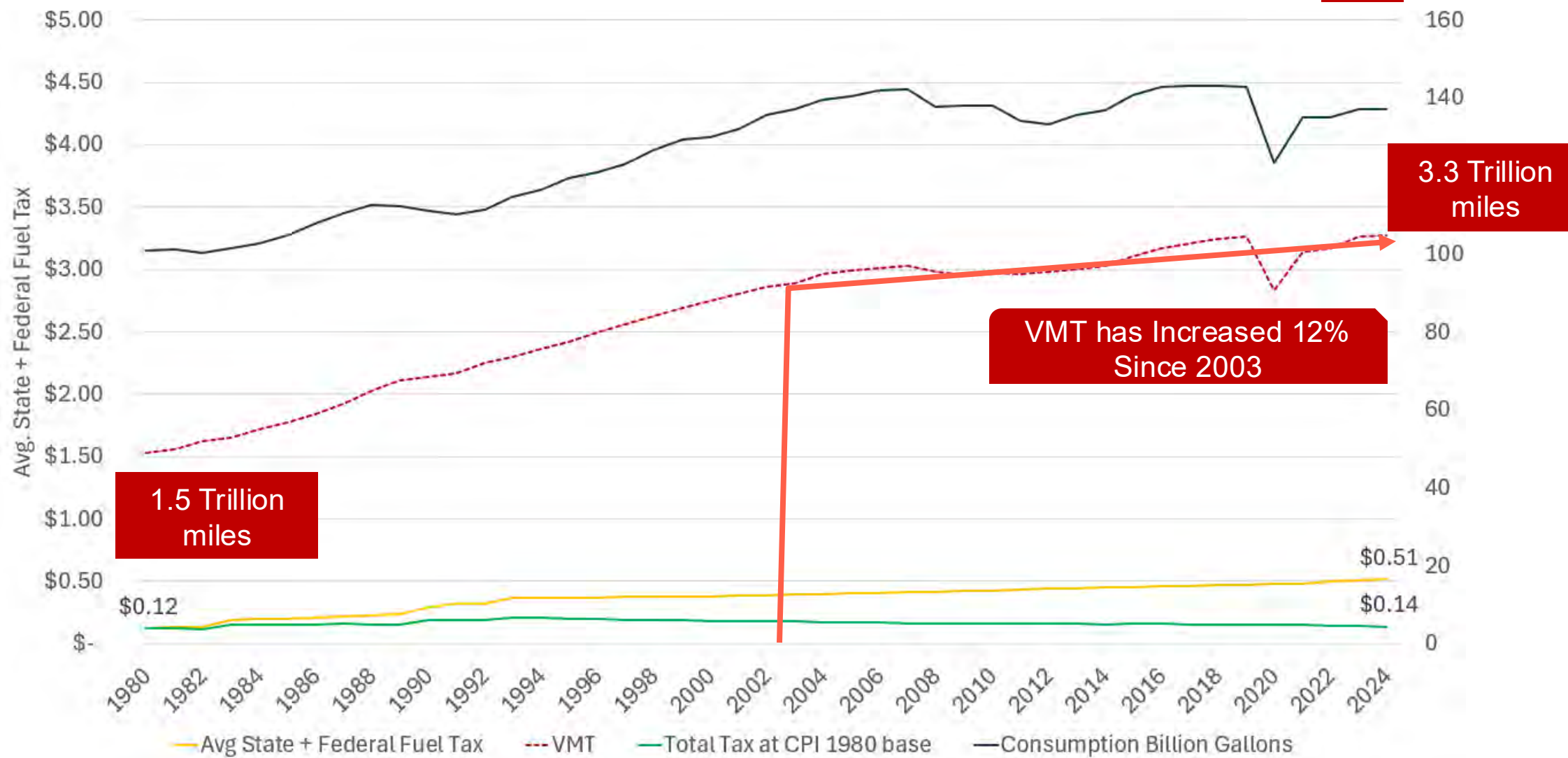


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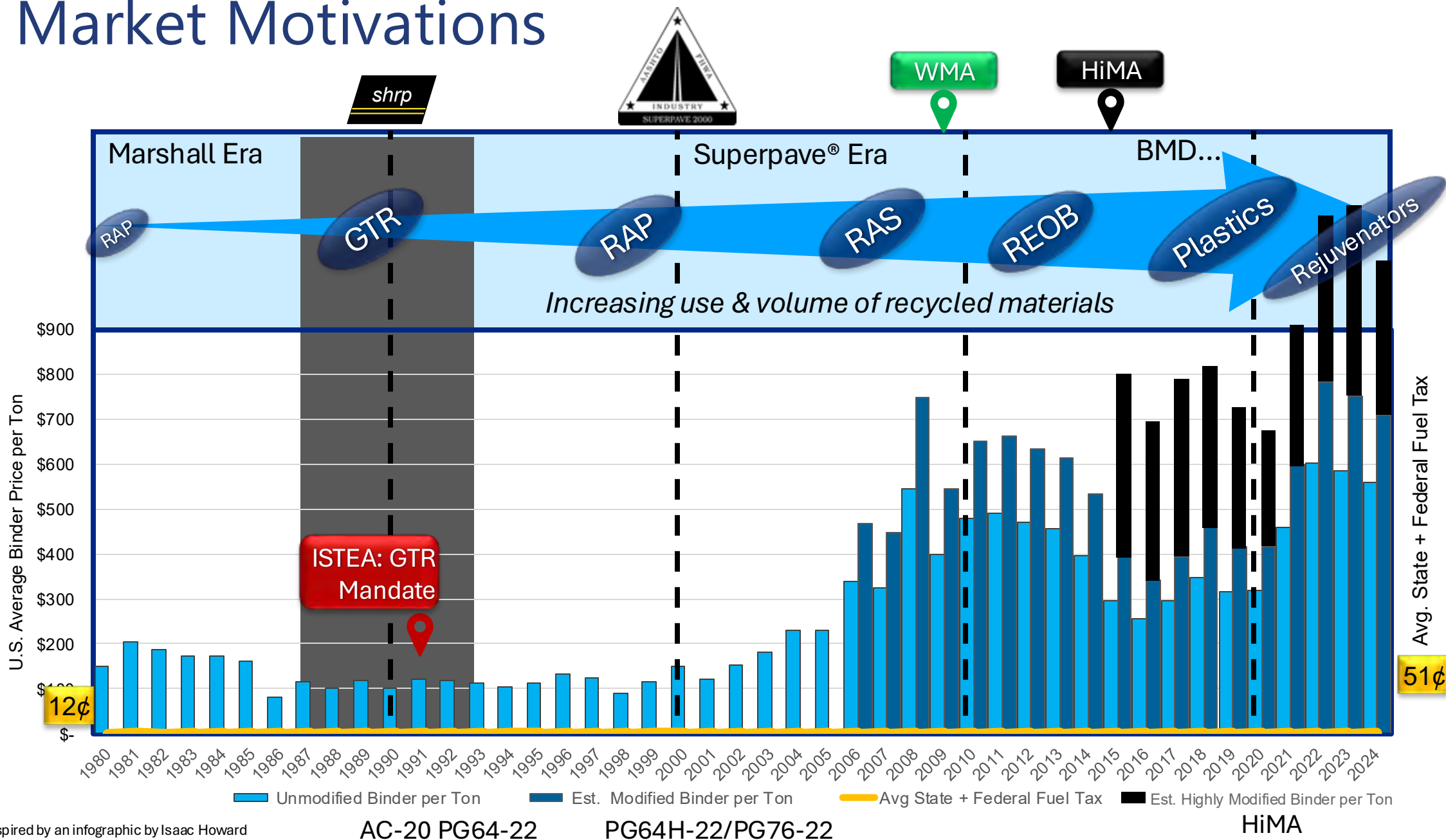


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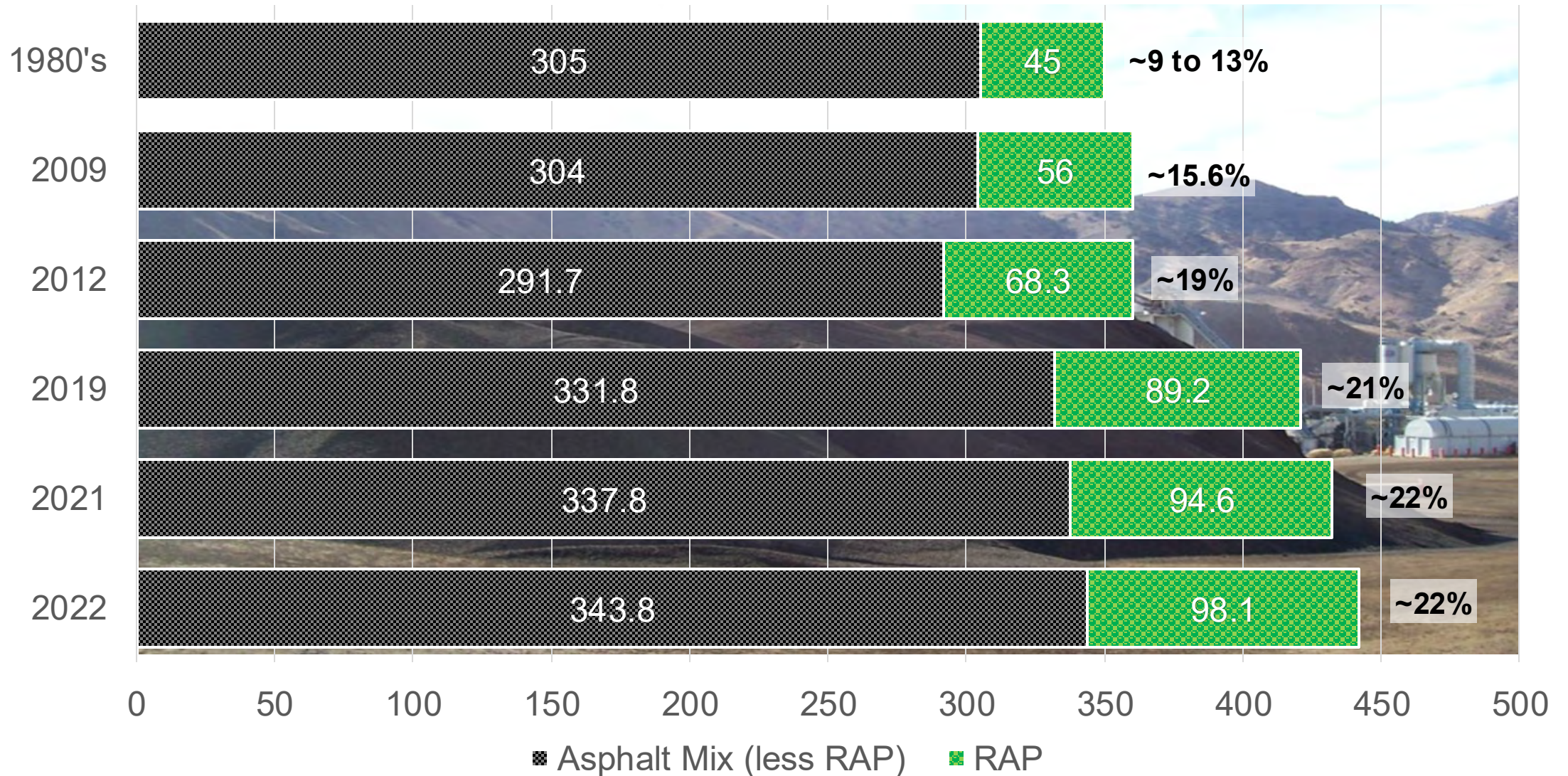
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Market Motivations



Market Trends – RAP (million tons)



Why



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In three words or less, describe why your State is moving to BMD?

38 responses

less prescriptive specs
effective simple straight
improved performance dura
rutting and cracking
check a box
improve quality
follow the pack
increase performance
longer lasting pavements
utilize more rap
push to do so
less cracking
volumetrics not working
improved quality
to better quality
quality
the feds
better performing pavemen
innovation
durability sustainability
improve mixes
better performance
better mix
cost effective mixes
improve
cost reduction
roadway longevity
workability
better performing mixes
baseline data field test
improved pavement perform
premature failed pavement
more applicable testing
measurable better options



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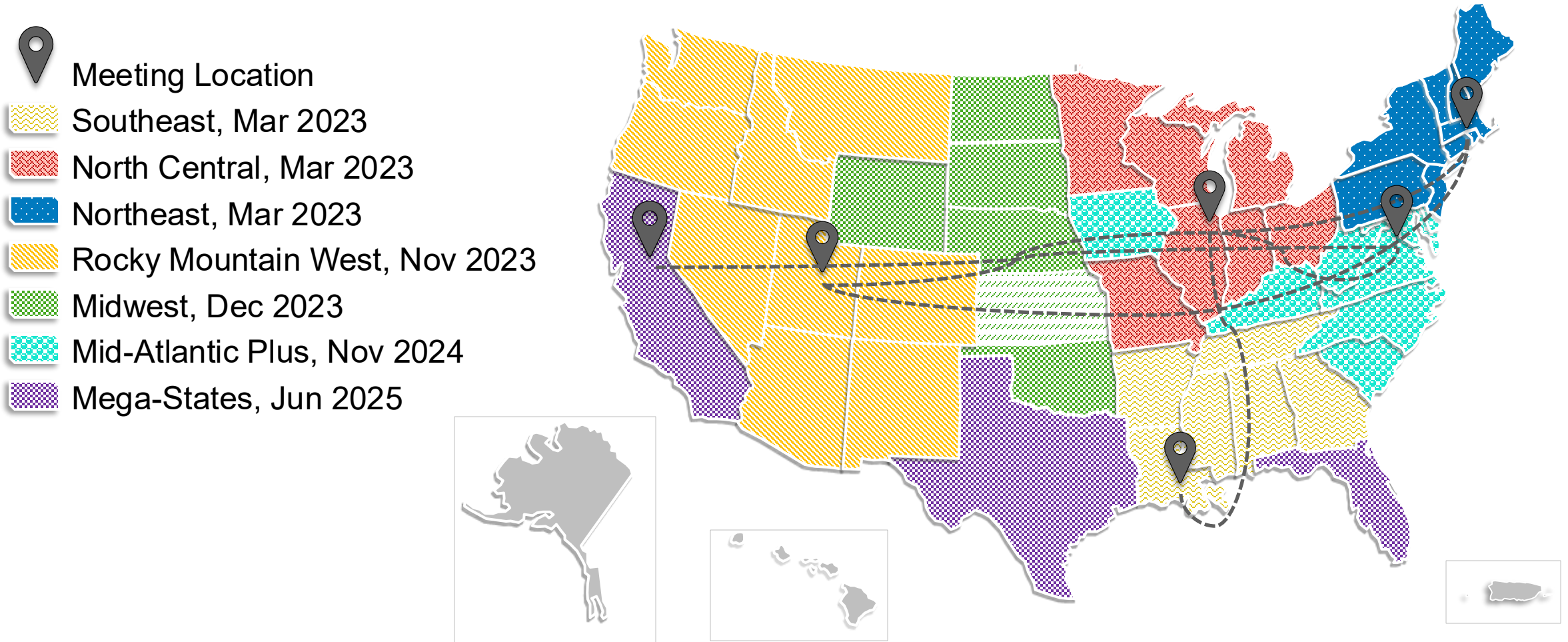
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Mentimeter

4

38

BMD Peer-to-Peer Exchange Participants



What is the Primary Motivation for State DOTs Moving to BMD?



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- 
- A background image showing a group of business professionals in a meeting. A woman in the foreground is pointing at a large screen or whiteboard, while others look on attentively.
- A. Greater Flexibility in Material Selection
 - B. Volumetrics Do Not Always Yield Optimal Performance
 - C. Support Responsible Use of Recycled Materials
 - D. Greater Opportunity for Innovation
 - E. A Combination of Motivators

Performance Challenges & Solutions

What are Your Common Performance Challenges?



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Challenges

Solutions

Block Crack

Pvt Preservation

Thermal Cracking

Testing

Cracking

Modifiers/Additives

Rutting

Mix Design

Stripping

Spec.'s

Raveling

Pvt Design

What



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Key Challenges



Management (M)



 - Northeast

Technical (T)



 - Northeast

Overlapping (TM)

TM1-Integration
Existing
Practices

TM3-
Collaboration
Info Sharing

TM2-Education
& Training

✓ - Northeast



Now



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M1-Change Management



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Challenge

Resistance to replacing traditional specifications with BMD due to unclear goals and priorities.



Opportunity

Alignment of BMD with performance goals through clear communication and understanding across various stakeholders.



ACTION

- Identify **Champions**
- Document and share BMD goals and scope.
- Emphasize eliminating poor-performing mixes.
- Align with State internal priorities.

M4-Resource Allocation

- Phase investment plans.
- Find and develop a qualified workforce.
- Assess equipment & staffing needs.
- Secure funding.



Resource planning to justify investments & support sustainable BMD adoption.



Limited funding, personnel, or equipment for implementation.

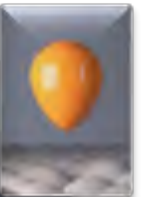


M6-Stakeholder Engagement

- Establish an agency – industry task force.
- Organize stakeholder forums, feedback loops, & workshops.
- Tailor outreach to small & large contractors, highlighting mutual benefits.

Early engagement & improved communication to unify support for better implementation.

Uneven buy-in across stakeholders.



Communication: Got Taskforce?

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Image: ChatGPT 4o

T1-BMD Test Validation



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Challenge

Lack of a standard validation framework and timely data collection; need for linking laboratory BMD test results with field performance.

Opportunity

Validation, using multiple approaches, builds credibility and confidence in BMD tests and their criteria.



ACTION

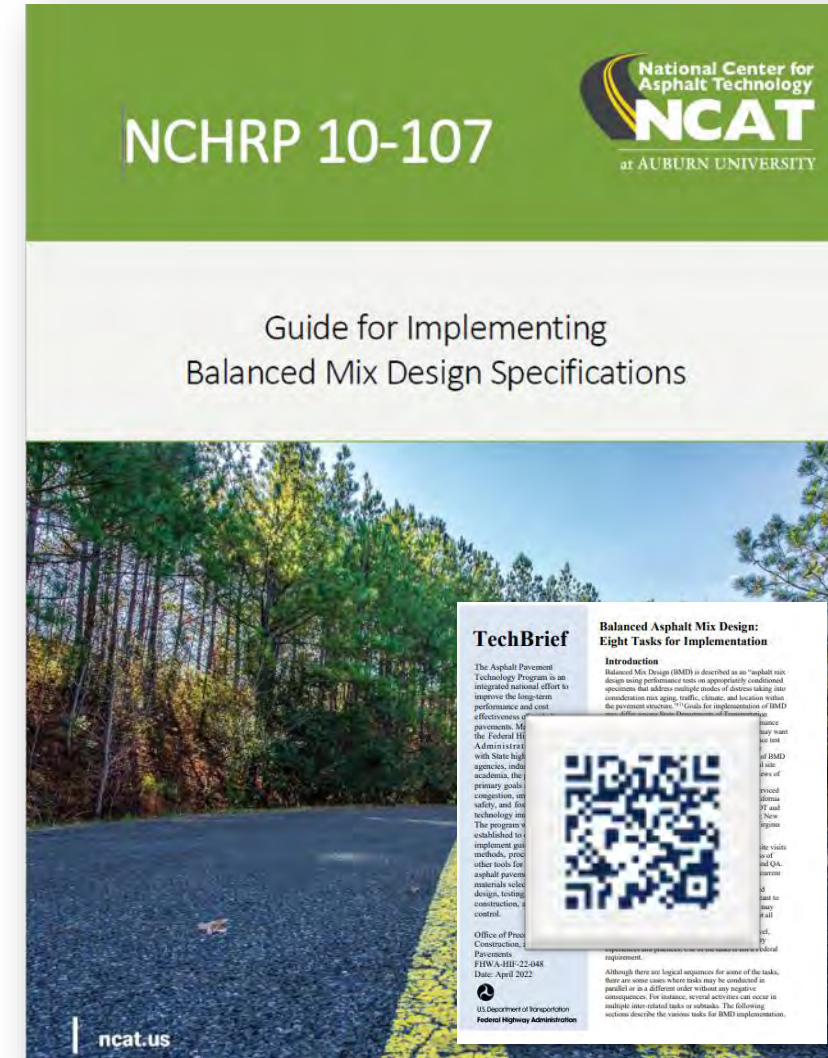
- Create a standardized test validation framework.
- Conduct validation experiments & leverage peer knowledge on validation practices
- Monitor in-service performance of asphalt mixtures & refine BMD test criteria.
- Collect & store field samples for future testing

Validation



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- 3.4 Relationship Confirmation and Criteria Development (60 months)

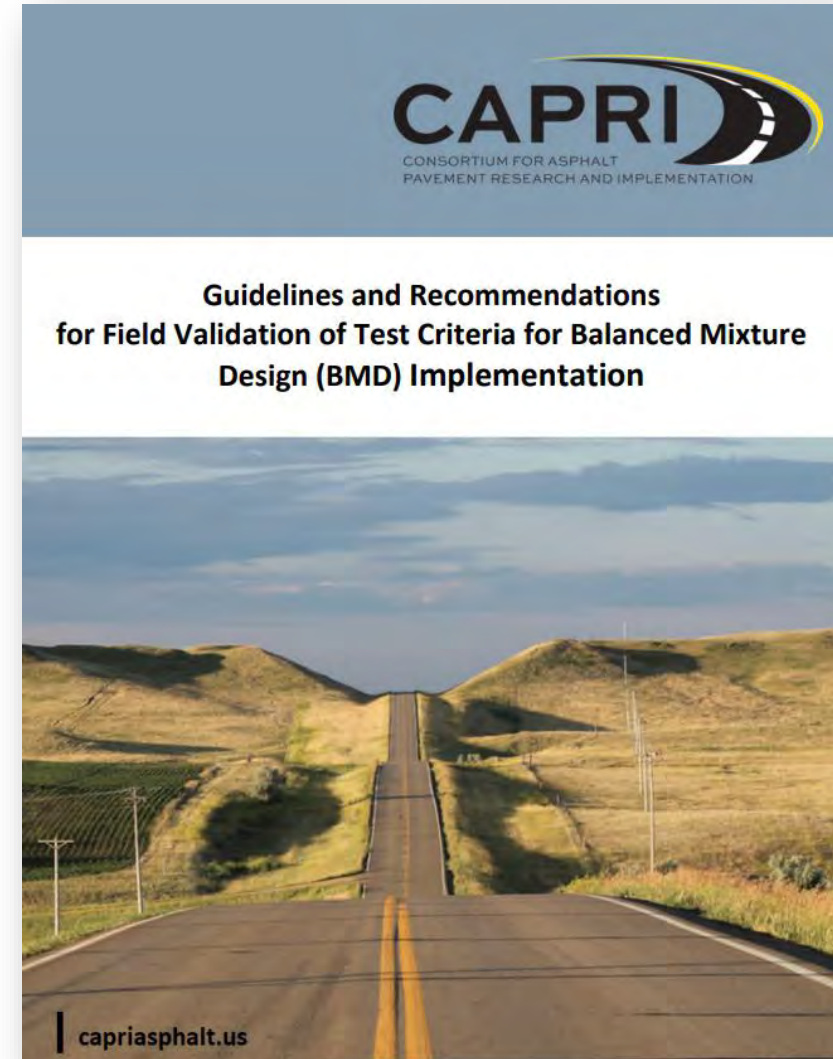


CAPRI Guidance for Open-Road Field Validation Sections



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- Advantages, Disadvantages, and Limitations
 - *Open-Road*
 - *Closed Test Track*
 - *Accelerated Pavement Testing*
 - *Network-level PMS*
- Types of Distresses
- Mixtures and Materials
- Test Sections (Number/Length)
- Geometry to Avoid
- Sampling, Conditioning, and Testing
- Performance Monitoring
- Forensic Investigation
- Data Analysis



Open Road BMD Validation Sections (CAPRI Style)



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2024
Preliminary Benchmarking
Focus: Surface Mixes
6 Sections
Goal: Validating Test Criteria

2026
Additional Validation Study



2024
Preliminary Benchmarking
Focus: Surface Mixes
6 Sections
Goal: Validating Test Criteria



WisDOT

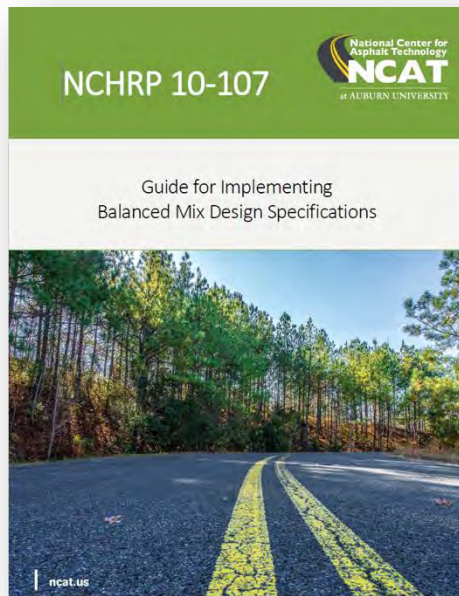
2022
Preliminary Benchmarking
Focus:
2 Virginia Mixes
High-RAP
3 10-15% RAP
6 Sections
Goal: Validating Test Criteria

2025



TDOT
Department of
Transportation

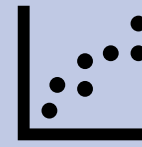
Beyond the Guide



Initial
Implement-
ation



Projects &
Studies

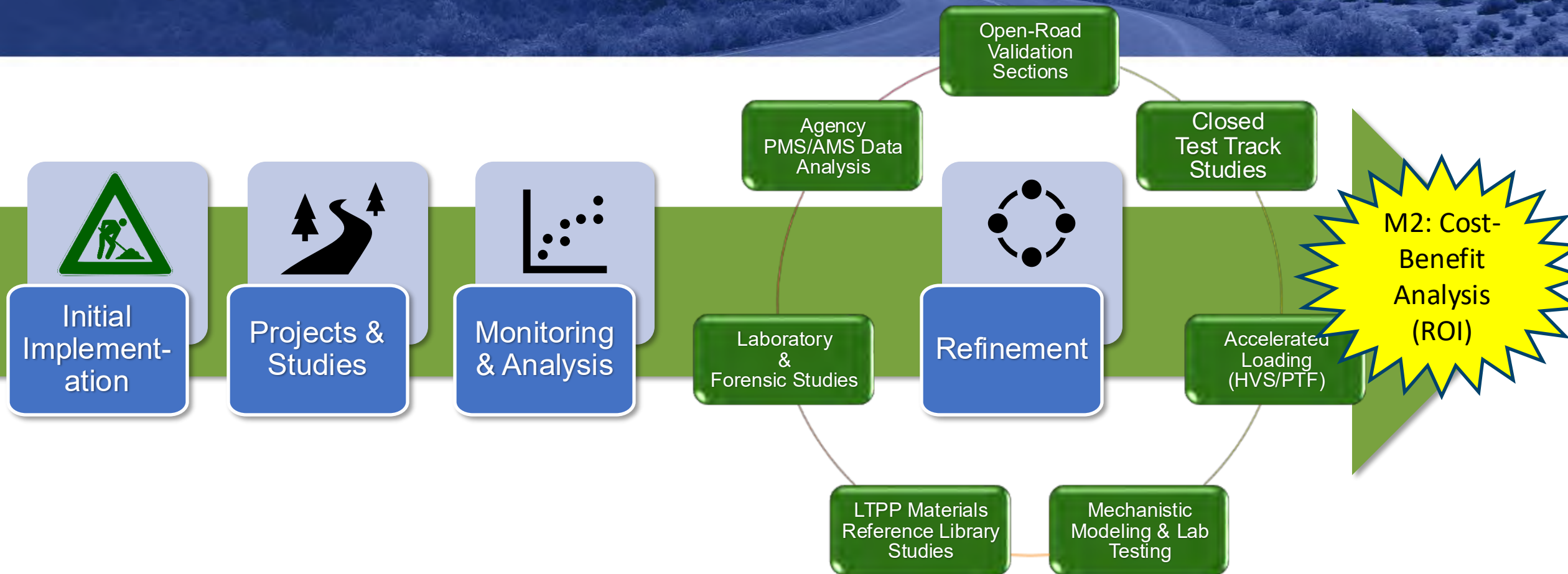


Monitoring
& Analysis



Refinement

Beyond the Guide



Validation Techniques & Case Studies

Validation Techniques for Setting BMD Test Criteria



Foreword

The development and validation of test criteria for asphalt mixtures are critical to the successful implementation of balanced mix design (BMD), ensuring long-term pavement durability, cost-effectiveness, and sustainability. Methods such as benchmarking, open road test sections, modeling, heavy vehicle simulation (HVS), accelerated loading facilities (ALF), test tracks, pilot projects, and forensic studies each offer unique strengths and limitations. No single approach fully addresses the diverse requirements posed by varying pavement types, traffic conditions, and environmental factors. Agencies must, therefore, strike a balance between rigorous evaluation and practical considerations, including time constraints and available resources. Integrating multiple techniques can enhance confidence in the validation of outcomes while reducing risk.

This document provides concise guidance on available validation techniques, highlights their advantages and challenges, and provides a framework for implementation. Supported by real-world case studies from state departments of transportation (DOTs) and other agencies, this resource aims to offer practical insights into successful validation strategies for BMD performance tests.

Validation Techniques

The following summarizes validation techniques for setting test criteria in asphalt BMD.



Benchmarking involves testing existing mixtures with selected or proposed **laboratory tests**, like the Hamburg Wheel Tracking Test (HWTT) to assess rutting resistance or the Indirect Tensile Asphalt Cracking Test (IDEAL-CT) to assess cracking resistance. This provides agencies with a set of baseline metrics. It is cost-effective and relatively quick. This technique is best used for early-stage validation of mix designs and establishing initial thresholds for specific tests. However, initial thresholds lack field validation and must be refined.



Open Road Test Sections entail constructing full-scale pavement sections on actual roadways to evaluate performance under real, yet consistent, traffic and environmental conditions over time. They provide valuable real-world data reflecting local conditions and long-term behavior, but are time-intensive, costly, and subject to variability in traffic, climate, and potential variations in support conditions. This approach is best for validating mix designs for high-traffic or critical roadways and verifying laboratory results with field performance. (See: [CAPRI Report](#))



Modeling with Laboratory Data involves leveraging laboratory tests and mechanistic-empirical models to predict asphalt mix performance based on mechanistic properties, often with transform functions developed to correlate these predictions with BMD index tests. This approach is rapid and cost-effective, enabling simulation of various traffic and environmental scenarios while integrating lab-based index test results. However, its accuracy relies on quality input data and may oversimplify complex field interactions. It is best suited for preliminary evaluations, optimizing validation plans by linking mechanistic predictions to index test outcomes and supporting other validation methods by forecasting long-term performance.



Heavy Vehicle Simulation (HVS)/Accelerated Loading Facilities (ALF) employs mobile or stationary equipment to apply controlled, repetitive loading to pavement sections, simulating years of traffic in months. This method accelerates pavement distress, provides repeatable results, and

Validation Techniques for Setting Test Criteria



Case Study: New England Forensic Study

Objectives

The objective of this case study is to demonstrate how forensic analysis can be utilized to select appropriate Balanced Mix Design (BMD) tests by evaluating asphalt mixes with known field performance. This approach will:

Benefit
Forensic analysis was leveraged to identify existing mixtures with good performance (HWTT and IDEAL-CT) to establish initial thresholds.

Background

The New England DOTs, which included Massachusetts, New Hampshire, and Vermont, were seeking to establish initial thresholds for BMD tests.

Methodology

The study conducted forensic analysis on existing mixtures with known field performance to establish initial thresholds for BMD tests.

Results (to-date)

The study identified initial thresholds for BMD tests based on forensic analysis of existing mixtures with known field performance.

Validation Techniques for Setting Test Criteria



Case Study: MassDOT with Modeling

Objectives

To develop a mechanistic-empirical Balanced Mix Design (BMD) approach for Massachusetts (MassDOT) using

Benefit
The study provided a mechanistic-empirical BMD approach for MassDOT, which will be used to establish initial thresholds for BMD tests.

Background

MassDOT is seeking to establish initial thresholds for BMD tests based on a mechanistic-empirical approach.

Methodology

The study conducted a mechanistic-empirical BMD approach for MassDOT, which will be used to establish initial thresholds for BMD tests.

Results (to-date)

The study identified initial thresholds for BMD tests based on a mechanistic-empirical approach.

Validation Techniques for Setting Test Criteria



Case Study: WisDOT Open-Road Test Sections

Objectives

To establish initial thresholds for BMD tests based on open-road test sections for Wisconsin (WisDOT).

Benefit
The study provided initial thresholds for BMD tests based on open-road test sections for WisDOT.

Background

WisDOT is seeking to establish initial thresholds for BMD tests based on open-road test sections.

Methodology

The study conducted open-road test sections for WisDOT, which will be used to establish initial thresholds for BMD tests.

Results (to-date)

The study identified initial thresholds for BMD tests based on open-road test sections.

Validation Techniques for Setting Test Criteria



Case Study: ND DOT Benchmarking

Objective

To establish initial thresholds for BMD tests based on benchmarking for North Dakota (ND DOT).

Benefit

The study provided initial thresholds for BMD tests based on benchmarking for ND DOT.

Background

ND DOT is seeking to establish initial thresholds for BMD tests based on benchmarking.

Methodology

The study conducted benchmarking for ND DOT, which will be used to establish initial thresholds for BMD tests.

Results (to-date)

The study identified initial thresholds for BMD tests based on benchmarking.

The study identified initial thresholds for BMD tests based on benchmarking.

The study identified initial thresholds for BMD tests based on benchmarking.

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The study identified initial thresholds for BMD tests based on benchmarking.

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The study identified initial thresholds for BMD tests based on benchmarking.



Dynamic Modulus (E*) paired with HWTT results were promising. Hamburg (HWTT) results were very promising. Threshold Refinement: Forensic analysis of failed pavements helped set conservative HWTT thresholds, ensuring mixtures meet performance targets. Successful pavements supported higher performance thresholds. Quantifying Service Life: Dynamic modulus results of unconditioned test mixture conditioned states were assessed using the AASHTO Parameter ME. The results showed that moisture-induced damage can have a significant impact on pavement life. Out of the three distresses, rutting was the most sensitive to moisture-induced damage, where some mixtures could experience a reduction in life of more than 50 percent.

a. At the lower OBC production tolerance limit.
b. At the lower OBC limit, combined with the upper aggregate gradation production tolerance.
c. At the lower OBC limit, combined with the lower aggregate gradation production tolerance.
6. How can a Pass/Fail criterion for selected tests be determined? A benchmarking experiment was conducted with 21 plants produced 12.5-mm Superpave mixtures (PG 640-28 binder) using IDEAL-CT at 25°C. Statistical analysis with a preliminary CT₉₀ criterion of a 90, validated using AASHTO's Pavement Mechanistic-Empirical Design (PMED) predictions.

Results (to-date)

The protocol established: HWTT criteria: 12.5 mm rut depth after 20,000 passes, no stripping inflection point before 15,000 passes (SP) before 15,000 passes at 40°C.

Preliminary Criteria: WisDOT's HWTT criteria (12.5 mm rut depth, no stripping inflection point before 15,000 passes) and IDEAL-CT (CT₉₀ index > 90) were tested, with HWTT showing potential as a faster rutting test. **Recommendations**
• Monitor test section field performance to establish lab-to-field correlations, with regular visual inspections for rutting and cracking.
• Investigate lab-to-field test result differences by standardizing mix reheating, splitting, and conditioning procedures, followed by a round-robin experiment.
• Refine test section mixtures in a single lab to establish baseline values for future correlations.
• Develop a formal test section training program for IDEAL-CT, HWTT, and HWTT to ensure consistency.
• Conduct additional laboratory research with corrective BMD tests to refine initial thresholds.

Test	Std. Dev. (n)	90% Typical Threshold	Interpretation
HWTT	15,360	4,700 ± 12,500	Good
IDEAL-CT	8	2.2 ± 12.5	Good
HWTT	25	54.5 ± 36	Good
IDEAL-CT	28	417	Good
HWTT	52	56	Good
IDEAL-CT	52	56	Good

Recommendations
• Continue Annual Benchmarking as ND DOT advances BMD into practice.
• Continue Round Robin participation in NCAT test effort.
• Promote Industry Collaboration: Share benchmarking results with contractors via the Dakota Asphalt Pavement Association to encourage BMD adoption, highlighting durability benefits.

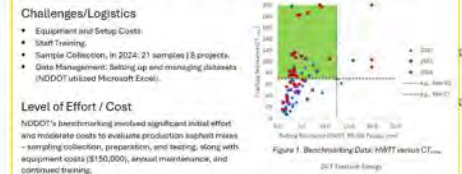


Figure 1. Benchmarking Data: HWTT versus CT₉₀



Figure 2. Benchmarking Data: HWTT versus CT₉₀

Coming February 2026

Documented Benefits of BMD


U.S. Department of Transportation
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LINKING INCREASED CRACKING RESISTANCE TO ENHANCED ASPHALT OVERLAY DURABILITY IN ILLINOIS

The Illinois Department of Transportation (IDOT) implemented the Track Test (HWT) in 2013 at the Illinois Center for Transportation (ICT) at the University of Illinois. The study led to three research studies to develop the Illinois Flexible Pavement (IFP) (ICT R27-128), and compare early field performance to laboratory test properties (ICT R27-129). An additional project to identify an aging protocol for I-FIT (ICT R27-161) study included

project included pre-construction distress surveys to map existing pavement conditions, followed by post-construction distress surveys conducted over the first several years of service to monitor pavement performance.

The combined dataset revealed a nonlinear inverse relationship between Δ CRS and production FI, indicating higher production FI values generally corresponded with lower rates of CRS deterioration, and thus better pavement performance.

Key Takeaways

Data from these HMA overlay projects demonstrate that cracking resistance, as determined by the I-FIT FI, has a nonlinear inverse relationship with the average change in pavement performance. As a result, higher FI values were generally associated with reduced transverse cracking and slower pavement deterioration. IDOT plans to continue monitoring these projects to further validate and refine the specifications.

advised with the Superpave system but were never implemented, prompting the use of proprietary high-performance mixtures on critical projects.⁽⁹⁾

To overcome cost and supply constraints associated with proprietary mixtures, NJDOT collaborated with academia and industry partners to develop performance-engineered alternatives. It should also be noted that

Increasing FI from 5 to 20 cuts pavement deterioration rates for IDOT by up to 27 percent.

NEW JERSEY'S EXPERIENCE WITH BMD: NETWORK LEVEL BENEFITS

New Jersey DOT (NJDOT) began adoption of Superpave in the mid-1990s and fully implemented in 2001 standard specifications with an initial design compaction level of 125 gyrations ($N_{design} = 125$), which was designated for pavements on very high traffic roadways

Since 2007, NJDOT's implementation of BMD increased pavements rated "Good" by 370 percent and reduced "Deficient" mileage by 63 percent.

EXTENDING PAVEMENT LIFE IN TEXAS WITH BMD: TEST TRACK INSIGHTS

In 2018, the Texas Department of Transportation (TxDOT) initiated a field experiment at the National Center for Asphalt Technology (NCAT) Test Track to evaluate the field performance of surface asphalt mixtures designed using volumetric mix design (VMD) and BMD approaches.⁽¹⁴⁾ The experiment included two test sections: S10 BMD and S11 VMD, both constructed as 2.5-inch mill-and-inlays over existing asphalt pavements with approximately 15 to 20 percent fatigue cracking.

maximum OT crack progression rate (CPR) of 0.45 lb.-in./in.². The S11 VMD mixture exhibited good rutting resistance but poor cracking resistance, while the S10 BMD mixture achieved balanced performance due to higher asphalt content.



content and 2.0 percent higher voids in mineral aggregate (VMA) compared to the S11 VMD mixture, while maintaining the design air voids and recycled binder ratio.

Table 2. Texas Mix Design Volumetrics (Data from Ref. 14).

TxDOT's BMD mixture at the test track extended pavement life by at least 38 percent with a reduced life-cycle cost of 17 percent.

HIGHER CRACKING TOLERANCE LEADING IMPROVED PAVEMENT PERFORMANCE IN VIRGINIA

The Virginia Department of Transportation (VDOT) began considering the implementation of BMD in 2018. This initiative aimed to address three primary issues by incorporating performance-related requirements into asphalt mix design specifications: (1) poor cracking performance of surface asphalt mixtures resulting in reduced service life; (2) a widespread perception that mixtures were under-asphalted;

mixtures. The thresholds established were a maximum 7.5 percent mass loss for the Cantabro test, a minimum cracking tolerance (CT) index of 70 for the IDT-CT at 25°C, and a maximum 8.0 mm APA run depth at 64°C.

Subsequently, two VDOT BMD special provisions were then drafted and revised for use in pilot projects: (1) *Special Provision for High Reclaimed Asphalt Pavement (RAP) Content Surface Mixtures Designed Using Performance Criteria*, and (2) *Special Provision for Dense Graded Surface Mixtures Designed Using Performance Criteria*. In 2019, two field trials were conducted to design, produce, and place BMD asphalt mixtures incorporating combinations of different RAP contents, two binder grades, two recycling agents (RAs), and two warm mix asphalt (WMA) additives.⁽²⁰⁾ In 2020, five additional

Thus, an initial effort by researchers at the Research Council of Transportation (RCT) benchmark indicated several asphalt mixtures in 2015 to support mixtures containing 10 to 15 percent RAP. Three performance modes of inclusion in the Cantabro mass loss potential; (2) the intermediate temperature resistance; and (3) the intermediate temperature susceptibility. Initial criteria were developed to encourage approximately 50 percent graded, non-polymeric

modified surface through maintenance. This resulted in approximately 1.57 percent BMD designed using BMD

Assessing Performance To confirm the superior cracking test criteria performance of mixtures placed in surveys, Falling Weight Deflection (FWD) testing, field visits, and pavement condition surveys were conducted to assess pavement condition. In addition, information from VDOT's Pavement

(PMS) was analyzed. The performance of the mixtures were assessed relative to the initial mixture properties and the results of the BMD

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AUTHORS

Elie Y. Hajj (ORCID: 0000-0001-8568-6360), University of Nevada, Reno

Ilker Boz (ORCID: xxxx-xxxx-xxxx-xxxx), and Stacey Diefenderfer (ORCID: xxxx-xxxx-xxxx-xxxx), Virginia Transportation Research Council

Fan Yin (ORCID 0000-0003-4238-9387), National Center for Asphalt Technology

Benefits of Balanced Mix Design: Evidence from State Implementation Efforts

This Technical Brief highlights the benefits of implementing Balanced Mix Design (BMD) for asphalt mixtures by State Departments of Transportation (DOTs). While the full impact of BMD requires time to quantify, data from States with several years of implementation demonstrate measurable improvements in pavement performance and service life. These findings offer agency and industry stakeholders valuable evidence to support broader adoption of BMD to enhance mixture durability, optimize the use of innovative and recycled materials, and improve long-term cost efficiency of asphalt pavements.


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VDOT's BMD implementation showed that increasing the CT index from 70 to 100 improved cracking performance by 25 percent and deferred over \$6.8 million in maintenance costs.

to 100 could keep approximately 4.2 percent of otherwise deficient road segments in adequate condition, resulting in an estimated \$6.8 million in deferred maintenance costs for the analyzed year.

CONCLUSION

Quantifying the full benefits of BMD takes time, as measurable performance improvements typically emerge only after several years of in-service field data are available. Early findings from four lead States—Illinois, New Jersey, Texas, and Virginia—clearly indicate that BMD implementation can result in improved pavement performance.

Each State applied a different approach to assess the benefits, yet all demonstrated that BMD leads to enhanced durability, extended service life, and reduced maintenance needs. The presented data demonstrate that the BMD approach is key to building more durable and cost-effective asphalt pavements.

While initial implementation involves commitment, collaboration, and investment in testing and data collection from all stakeholders, the long-term evidence shows a strong return on this collaborative effort. BMD is more than a technical enhancement to the mix design—it is a strategic shift in pavement management, enabling State DOTs to move from reactive maintenance toward proactive preservation and ensuring a better performing roadway network.

OVERALL SUMMARY

The four case studies clearly demonstrate that the integration of mechanical testing into asphalt mix design yields quantifiable, positive impacts on pavement performance.

- Illinois used the I-FIT to show a clear nonlinear inverse correlation between FI values and transverse cracking, meaning higher cracking resistance directly leads to improved pavement longevity and a lower rate of CRS (Condition Rating Survey) deterioration.
- New Jersey transformed its network-level strategy by integrating six specific BMD mixtures into a proactive preservation program. This strategic effort, supported by mechanical tests like the OT and APA, reversed the network condition, increasing "Good" roads by 370 percent and meeting the "state-of-good-repair" goal by 2022.
- Texas experiment at the NCAT Test Track provided compelling side-by-side evidence: a BMD mixture, optimized with higher asphalt content to achieve balanced rutting and cracking resistance, extended pavement life by at least 38 percent (5.5 MESAIs) compared to a VMD (Volumetric Mix Design) control. Despite a 6 percent higher material cost, the BMD mixture was 17 percent more cost-effective from a life-cycle perspective.
- Virginia demonstrated the economic value of higher cracking resistant asphalt mixtures through CT index. Analysis showed that increasing the production CT index from 70

able asphalt pavements has prompted a design methodologies. Historically, State on (DOTs) have relied on volumetric mix fall short in ensuring long-term pavement the increasing use of innovative and limitations have contributed to frequent ased life-cycle costs.

) has emerged to address these durability

Coming February 2026

T2-Testing Procedures & Protocols

- Develop protocols for handling, short-term and long-term aging, and conditioning of asphalt mixtures for BMD testing.
- Assess the need for multiple tests to address different cracking types and varying climatic zones.



Standardization improves test repeatability by greater focus on consistent specimen fabrication and provides tailored testing conditions for climate-specific cracking types.



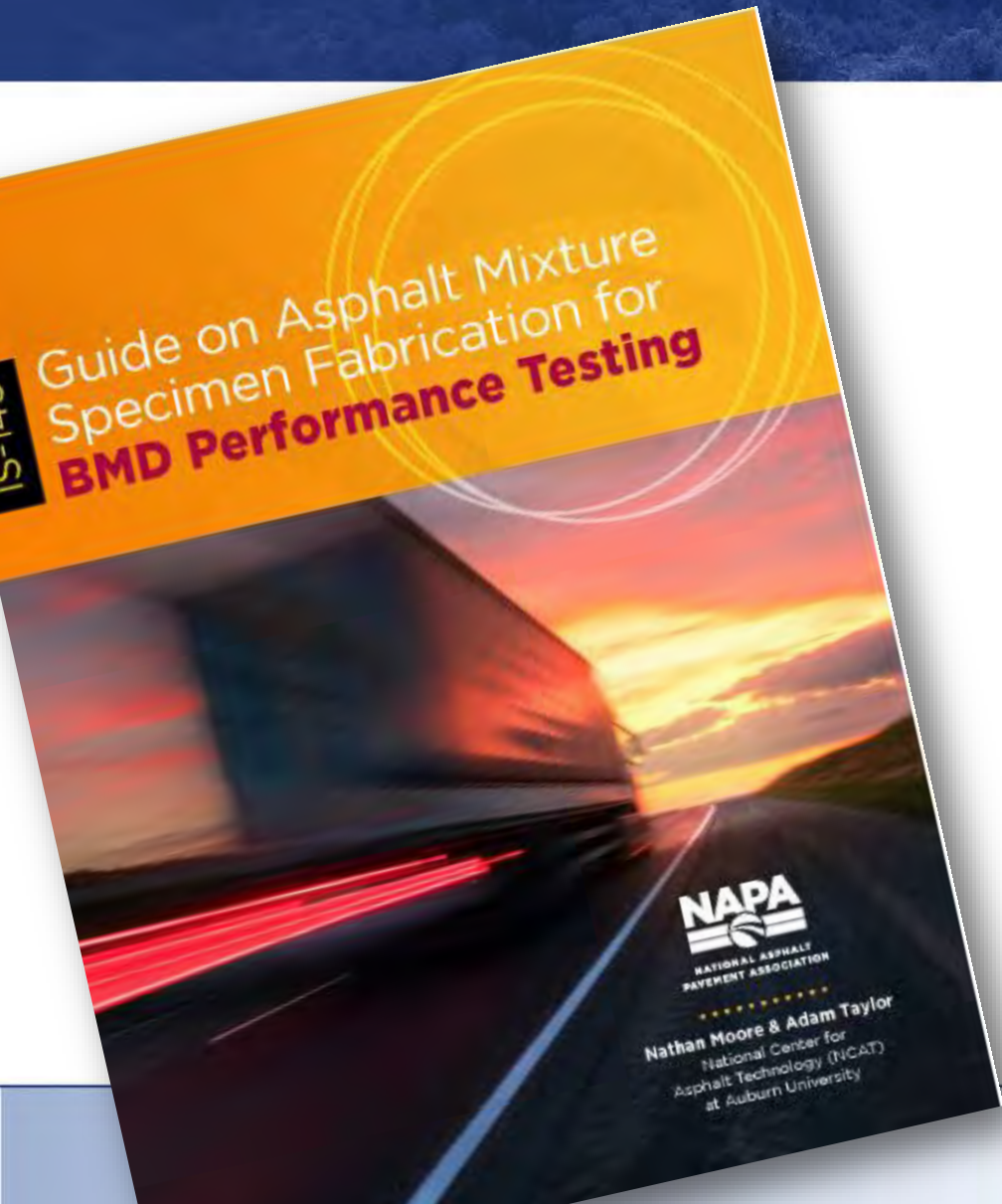
Inconsistent or lack of sample handling, aging, & conditioning methods, including lag & dwell.



Sample Preparation Guide



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- As the asphalt industry moves toward BMD and performance testing it is important to remember that the preparation of the samples being tested can affect the results of the testing.
- The *Guide on Asphalt Mixture Specimen Fabrication for BMD Performance Testing* is helpful in obtaining consistent results



The Challenge of Time/Logistics



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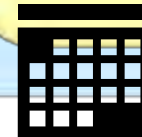
Sample Mix
for QA

Lag Time
(with & without
Reheating)



Compact
Test
Specimen

Dwell Time



Condition &
Test
Specimen

AASHTO R 121-24 (TS 2c)

Method A

Compacted
Specimen
85°C

120 ± 0.5 h
 $85 \pm 3^\circ\text{C}$

Method B

Uncompacted
Loose Mixture
85°C

120 ± 0.5 h
 $85 \pm 3^\circ\text{C}$

Method C

Uncompacted
Loose Mixture
95°C

$t_{\text{oven}} = \text{CAI}$

Method D

Uncompacted
Loose Mixture
100-125°C

20 ± 0.5 h

Method E

Uncompacted
Loose Mixture
135°C

8 ± 0.5 h $135 \pm 3^\circ\text{C}$

$$t_{\text{oven}} = \text{CAI} = \sum_{i=1}^N 0.0437 d^{-0.426} e^{\frac{-1601.167}{T_i}}$$

AASHTO R 121-24 (TS 2c)



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State	Short-Term Aging		Long-Term Aging		AASHTO R 121-24
	Mixture	Conditioning	Mixture	Conditioning	
CA	Uncomp.	4 hrs at Tcomp.	Uncomp.	20 h at 100°C	Method D
IL	Uncomp.	2 hrs at 135°C	Comp.	72 h at 95°C	N/A
LA	Uncomp.	2 hrs at 135°C	Uncomp.	120 h at 85°C	Method A
ME	Uncomp.	2 hrs at 135°C	Uncomp.	20 h at 100°C	Method D
MA	Uncomp.	2 hrs at 135°C	Uncomp.	20 h at 100°C	Method D
OR	Uncomp.	2 hrs at 135°C	Uncomp.	24 h at 95°C	Method C
TX	Uncomp.	2 hrs at 135°C	Uncomp.	20 h at 100–125°C	Method D
WI	Uncomp.	4 hrs at 135°C	Uncomp.	6 h at 135°C	Method E

NCHRP

PROJECT NO. 09-70

Guidelines for Incorporating Aging Effects on Balanced Mix Design for Quality Assurance

Method A

Compacted Specimen
85°C

120 ± 0.5 h
85 ± 3°C

Method B

Uncompacted Loose Mixture
85°C

120 ± 0.5 h
85 ± 3°C

Method C

Uncompacted Loose Mixture
95°C

$t_{\text{oven}} = \text{CAI}$

Method D

Uncompacted Loose Mixture
100-125°C

20 ± 0.5 h

Method E

Uncompacted Loose Mixture
135°C

8 ± 0.5 h 135
±3°C

TM2-Education & Training



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Challenge

Limited formal training on BMD test methods and data interpretation, leading to skill gaps in BMD implementation and analysis.



Opportunity

Training programs and workshops on BMD test methods and data interpretation, developing skilled staff for continued implementation.

- Collaborate with universities and industry partners to develop hands-on BMD training modules.
- Develop and deliver BMD certification programs.
- Include test method demonstrations, data analysis, and interpretation exercises in the training.

Lots of Resources

AIEI

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AIEI Training Opportunities

✓ BMD Implementation Workshop

✓ BMD Webinar Series

✓ High-Reclaimed Asphalt Pavement (RAP) Mixture Strategies

Thoughts



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Sub-Category	Challenge	Opportunity	Action
M1— Change Management	Resistance to replacing traditional specifications with BMD due to unclear goals and priorities.	Alignment of BMD with performance goals through clear communication and understanding across various stakeholders.	- Identify internal champions to foster culture shift. - Document and share BMD goals and scope. - Emphasize improving asphalt mixture performance. - Align with State internal priorities
M2— Cost-Benefit Analysis	Limited business case for BMD investments.	Demonstration of lifecycle cost savings and performance gains to decision-makers and stakeholders.	- Develop a comprehensive business case outlining costs and benefits. - Highlight performance gains.
M3— Specifications and Risk Management	Uncertainty around acceptance of BMD mixtures, recycled material usage, and associated budget risks.	Co-development of adaptable performance specifications aligned with BMD, while managing performance risks.	
M4— Resource Allocation	Limited funding, personnel, or equipment for implementation.	Resource planning to justify investments and support sustainable BMD adoption.	
M5— Implementation Planning	Lack of formalized plan for BMD rollout.	Structured implementation into manageable, trackable tasks for streamlined adoption.	
M6— Stakeholders Engagement	Uneven buy-in across stakeholders	Early engagement and improved communication to unify support for better implementation.	- Estimate and communicate benefits. - Organize outreach to small and large contractors, highlighting mutual benefits.

Sub-Category	Challenge	Opportunity	Action
TM1— Integration with Existing Practices	Lack of integration of BMD into existing workflows and specifications, coupled with technical and operational disconnects between key agency groups/divisions (e.g., materials, construction, pavement management).	Compatibility of BMD with existing workflows and specifications, streamlined testing procedures, and improved coordination across agency groups for effective adoption.	- Adapt workflows and specifications to integrate BMD. - Define roles and responsibilities across agency groups, consultants, and contractors. - Establish clear communication channels to ensure seamless coordination.
TM2— Education & Training	Limited formal training on BMD test methods and data interpretation, leading to skill gaps in BMD implementation and analysis.	Training programs and workshops on BMD test methods and data interpretation, developing skilled staff for continued implementation.	- Collaborate with universities and industry partners to develop hands-on BMD training modules. - Develop and deliver BMD certification programs. - Include test method demonstrations, data analysis, and interpretation exercises in the training. - Plan for continuous training of new staff to address high turnover.
TM3— Collaboration and Information Sharing	Lack of cross-agency collaboration and knowledge sharing, with agencies working in isolation.	Increased cross-agency collaboration, pooling resources, and expertise to accelerate shared learning and adoption.	- Facilitate regional working groups and roundtables for cross-agency collaboration. - Share specifications, lessons learned, and templates across agencies. - Seek industry feedback to align with effective practices. - Bridge gap between research and practice.

Sub-Category	Challenge	Opportunity	Action
T1— BMD Tests Validation	Lack of a standard validation framework and timely data collection; need for linking laboratory BMD test results with field performance.	Validation, using multiple approaches, builds credibility and confidence in BMD tests and their criteria.	- Create a standardized test validation framework. - Conduct validation experiments and leverage peer knowledge on validation practices - Monitor in-service performance of asphalt mixtures and refine BMD test criteria. - Collect and store field samples for future testing.
T2— Testing Procedures	Inconsistent or lack of sample handling, aging, and conditioning methods	Standardization improves test repeatability by greater focus on consistent specimen fabrication and provides tailored testing conditions for climate-specific cracking types.	- Develop protocols for handling, short-term and long-term aging, and conditioning of asphalt mixtures for BMD testing. - Assess the need for multiple tests to address different cracking types and varying climatic zones.
		Reducing variability increases confidence in test results, enabling greater trust in mixture performance and supporting innovation.	- Conduct inter-laboratory and sensitivity studies to assess variability of and improve consistency in BMD test results. - Quantify variability between laboratory and plant-produced asphalt mixtures. - Identify and raise awareness of production factors that may influence BMD test results. - Offer technical training to stakeholders. - Consider the number of replicates.
		Data can inform decision-making and specifications.	- Create a centralized and structured database template. - Build or adopt templates to link mix design results with field performance. - Incorporate many data fields with raw data.
		Acceptance based on performance ensures quality and expected value while maintaining in-place density and smoothness.	- Adopt mix design verification protocols using verification lots, test strips, or batch mixtures at the start of production. - Implement go/no-go BMD test criteria. - Define lot and subplot sizes, along with sampling frequency while considering testing time and variability. - Establish payment structures closely aligned with validated BMD tests that reliably reflect field performance and account for production variability to enable justified performance-oriented incentives or penalties. - Address sampling responsibilities and lag/dwell time impact on dispute resolution.*
		Advance specifications while balancing innovation and risk. BMD tests may replace some volumetric properties.	- Determine which volumetric and aggregate properties can be relaxed or eliminated. - Transition towards performance-oriented quality measures, such as percent within limits.

State Participants Key Takeaways (1/3)



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Start with a Plan



Define Your “Why”



Identify Champions



Account for Staffing Needs



Invest in Training

State Participants Key Takeaways(2/3)



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Start Validation Early



Transition Mindset



Collaborate with Industry



Leverage Peer Resources



Utilize Existing Funding

State Participants Key Takeaways(3/3)



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Build a Strong Data System



Encourage Regional Collaboration



Plan for Setbacks

Wrap Up

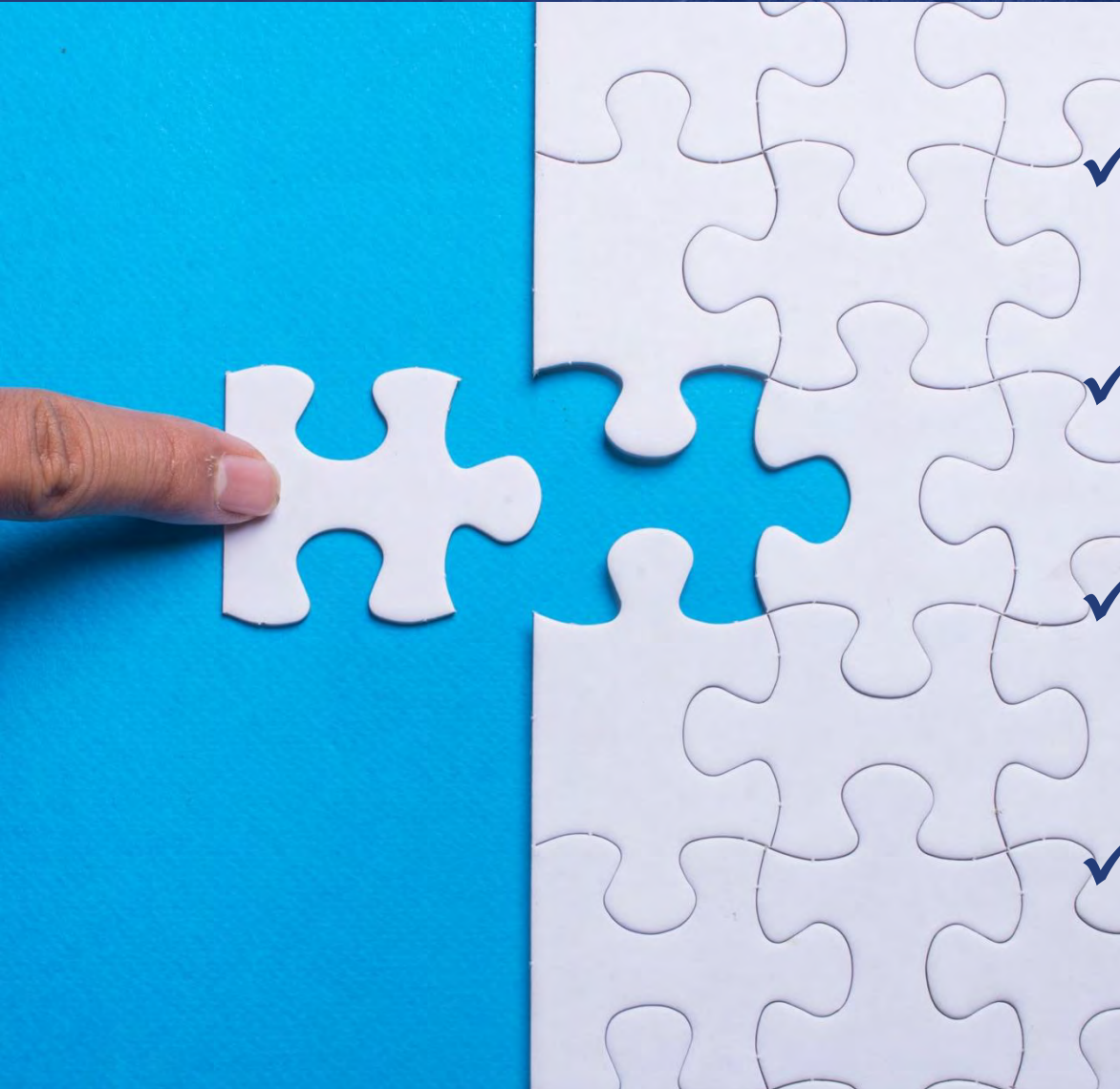
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**Key
Takeaways**

What are Your Takeaways?



- ✓ Resource Constrained Environment
- ✓ Volumetrics do/will not address our current/future needs
- ✓ BMD will continue to evolve
- ✓ Are you part of the solution?

BALANCED MIX DESIGN (BMD) TIERED SYSTEM

ASPHALT
PERFORMANCE
CHARACTERISTICS

CRACKING • MOISTURE DAMAGE • SURFACE CHARACTERISTICS

RUTTING • LOAD / NON-LOAD RELATED

Tier 3

(Max reliance on mechanical tests)

- Retains ≤ 2 specification requirements related to performance characteristics.
- Includes mechanical tests extensively field validated.

Tier 2

(Moderate relaxation or removal of spec. requirements)

- Changes ≥ 3 specifications (≥ 1 constituent + ≥ 1 volumetric).
- Changes pertain only to properties tied to the targeted performance characteristic.

Tier 1

(Minimal relaxation from existing specs)

- Adjusts 1+ volumetric property.
- No changes to related constituent material requirements.
- Involves minimal specification changes.

WHERE FLEXIBILITY MEETS PERFORMANCE GOALS...

Q & A

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Thank you!

Derek Nener-Plante
derek@dnpinfrastructure.com



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