2023

Rocky Mountain West Peer Exchange on Balanced Mix Design (BMD)

Outcomes Summary

Salt Lake City, UT

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16. Abstract

Nine States from the Rocky Mountain West U.S. gathered for a peer exchange and discussion on implementation activities to support Balanced Mix Design (BMD). The peer exchange was sponsored by the Federal Highway Administration (FHWA). The nine States met to assess the state-of-practice for the technology, tools, and techniques in designing, verifying, and accepting asphalt mixtures for different layers within the flexible pavement structure, as well as for overlays of different pavements following BMD emerging practices. The peer exchange was held in Salt Lake City, Utah. This summary report focuses on agency motivations for considering BMD, the role of sustainability in BMD practice, implementation challenges, key takeaways, and emerging themes.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
BMD	Balanced Mix Design
CDOT	Colorado Department of Transportation
DOT	Department of Transportation
FHWA	Federal Highway Administration
GHG	greenhouse gas
HWTT	Hamburg Wheel Tracking Test
IDEAL-CT	Indirect Tensile Cracking Test
IDEAL-RT	Ideal Rutting Test
ITD	Idaho Transportation Department
LTOA	long-term oven aging
MDT	Montana Department of Transportation
NDOT	Nevada Department of Transportation
NMDOT	New Mexico Department of Transportation
OBC	optimum binder content
ODOT	Oregon Department of Transportation
PG	Performance Grade
PMS	pavement management system
QA	quality assurance
RAP	reclaimed asphalt pavement
RAS	reclaimed asphalt shingles
SIP	stripping inflection point
STIC	State Transportation Innovation Council
TSR	tensile strength ratio
UDOT	Utah Department of Transportation
UNR	University of Nevada, Reno
U.S.	United States
VMA	voids in mineral aggregates
WSDOT	Washington State Department of Transportation

INTRODUCTION AND PURPOSE

On November 29-30, 2023, nine States from the Rocky Mountain West United States (U.S.) gathered for a peer exchange on implementation activities to support Balanced Mix Design (BMD). The peer exchange was sponsored by the Federal Highway Administration (FHWA). The nine States met to assess the state-of-practice for the technology, tools, and techniques in designing, verifying, and accepting asphalt mixtures for different layers within the flexible pavement structure, as well as for overlays of different pavements following BMD emerging practices. The peer exchange was held in Salt Lake City, Utah.

This summary report focuses on agency motivations for advancing BMD into practice, the role of sustainability in BMD, implementation challenges, key takeaways, and emerging themes. It should be noted that all referenced specifications are not federal requirements unless otherwise noted.

PEER EXCHANGE GENERAL OVERVIEW

BMD focuses on designing asphalt mixtures to meet performance requirements rather than just volumetric requirements. Association of State Highway and Transportation Officials (AASHTO) PP 105-20 Standard Practice for Balanced Design of Asphalt Mixtures[1] describes four approaches for BMD, summarized as follows:

- ***Approach A — Volumetric Design with Performance Verification*** consists of using existing volumetric mix design along with additional mechanical tests and criteria.
- ***Approach B — Volumetric Design with Performance Optimization*** consists of using existing volumetric mix design to determine a preliminary optimum binder content (OBC) but allows moderate changes in asphalt binder content to meet mechanical tests criteria. This approach is slightly more flexible than Approach A.
- ***Approach C — Performance-Modified Volumetric Design*** allows some of volumetric properties to be relaxed or eliminated as long as the mechanical test criteria are satisfied. The mechanical test results are used to adjust either the preliminary asphalt binder content or mixture component properties and proportions. This approach is more flexible than Approach A and Approach B.
- ***Approach D — Performance Design*** does not use volumetric properties and relies on the mechanical test results to establish and adjust mixture components and proportions. This is the most flexible approach.

Participants

States represented at the BMD peer exchange included (Figure 1) (individual participants are provided in Appendix A):

- Arizona Department of Transportation (ADOT).
- Colorado DOT (CDOT).
- Idaho Transportation Department (ITD).
- Montana DOT (MDT).

[1]AASHTO PP 105 Standard Practice for Balanced Design of Asphalt Mixtures. American Association of State Highway and Transportation Officials, Washington, D.C., 2020. Use of this AASHTO specification is not a federal requirement.

- Nevada DOT (NDOT).
- New Mexico DOT (NMDOT).
- Oregon DOT (ODOT)
- Utah DOT (UDOT)
- Washington State DOT (WSDOT)

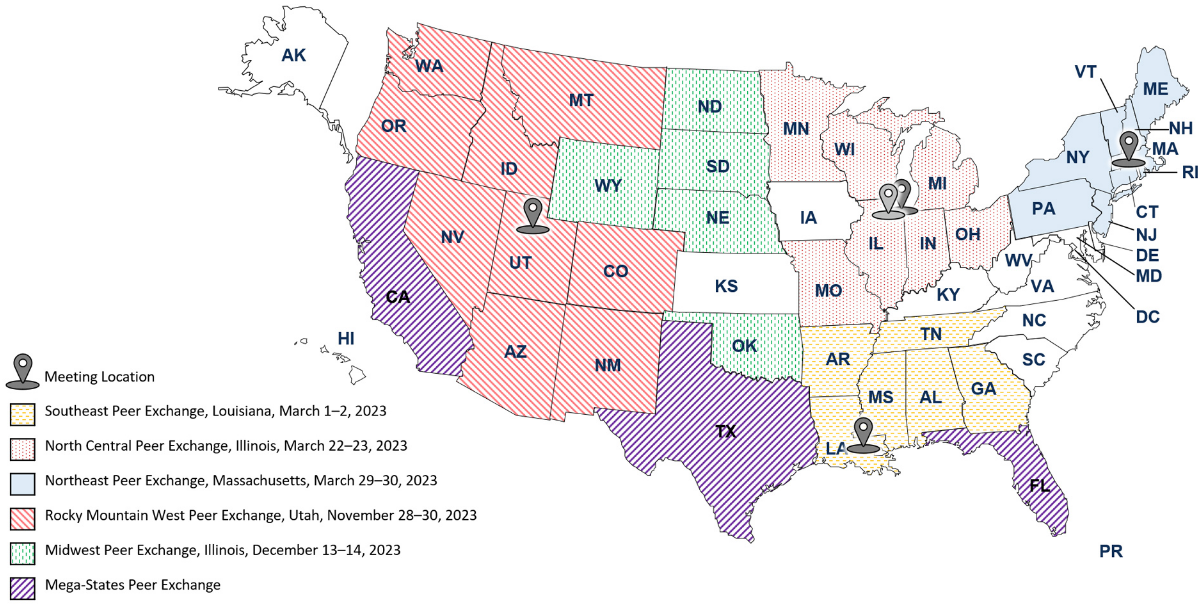

Figure 1. U.S. Map showing participating States in the Rocky Mountain West BMD Peer Exchange.

Agenda

Day 1 of the meeting focused on each State's existing efforts on BMD, while Day 2 focused on future efforts planned on BMD. The following items were included in the agenda:

- BMD status.
- BMD goals, scope, and approaches.
- Benchmarking studies.
- Validation efforts.
- Role of sustainability.
- Challenges and lessons learned.
- Next steps toward implementing BMD within each Agency and needs for moving forward.

Questionnaire

Three weeks before the peer exchange, the attendees from the nine participating States were asked to complete a short questionnaire pertaining to their BMD practices. Information was received from all nine State DOTs with a summary of the results presented in Appendix B.

Motivations for Considering Moves to BMD Approaches

In the U.S., the Superpave[2] volumetric mix design is primarily used for asphalt mix design. Since its implementation in the late 1990's and early 2000's, State DOTs have identified performance challenges related to the Superpave including cracking, raveling, and moisture damage[3], which have become the primary distresses controlling the service lives of asphalt pavements. A common motivation for changing from Superpave to BMD is that the traditional volumetric-based mix design procedure may not provide optimum performance for asphalt mixtures and lacks opportunities for innovation.

Reflective cracking, thermal cracking, and moisture damage were reported as a major concern for participating State DOTs as they considered BMD approaches.[3] Rutting was also noted as a primary mode of distress by five out of the nine State participants. State participants discussed how BMD mechanical tests will provide contractors the opportunity to use higher percentages of reclaimed asphalt pavement (RAP) content while retaining pavement performance. One State noted that they would like to define asphalt mixture quality based on performance rather than volumetrics. Concerns with volumetric properties, long-term pavement performance, limitations in available resources, and the ability to evaluate and quantify the impact of new materials on asphalt mixture properties are some of the most common reasons mentioned by the participating States for transitioning to BMD. For instance, some States noted that statewide funding for pavements is down and expressed a need for innovative solutions to meet projected decreased funding by extending pavement service life.

Role of Sustainability

State participants discussed how BMD mechanical tests allow them to assess the resistance of asphalt mixtures to common distresses and enable mix designers to better utilize more sustainable and innovative materials. This use of recycled or other innovative materials can help the States meet low carbon emission targets and meet longer life spans for pavements. State participants from Arizona, Colorado, Oregon, and Washington noted that their State is part of the FHWA Climate Challenge – Quantifying Emissions of Sustainable Pavements program (https://www.fhwa.dot.gov/infrastructure/climatechallenge/) and aim to identify BMD practices to help support sustainability initiatives. The participants discussed and identified opportunities and areas of exploration for integrating BMD into sustainability as follows:

- State participants have differing statewide priorities and legislation around sustainability. While some States are required to consider sustainability in processes or monitor/reduce greenhouse gas (GHG) emissions, others are facing pressure to not consider sustainability or are not allowed to consider GHG emissions when making decisions.

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[2]Superpave system was developed under the Strategic Highway Research Program (SHRP), which was a 5-year, $150 million applied research program authorized by the Surface Transportation and Uniform Relocation Act of 1987. $50 million of the SHRP effort was dedicated to Superpave.
[3]Distress Identification Manual for the Long-Term Pavement Performance Program (Fifth Revised Edition). FHWA-HRT-13-092, FHWA, U.S. Department of Transportation.

- For those States embracing sustainability, some Federal or other funding sources may be available to assist with BMD implementation.
- Two State legislatures are requiring Environmental Product Declarations (EPDs). One State noted that contractors are using the prospect of EPDs as a leverage to increase the RAP content in asphalt mixtures. Thus, the State is planning on using BMD to assure performance considering these potential changes.
- States noted the potential for BMD to improve long-term pavement performance and mitigate asphalt pavement cracking. This presents a movement towards sustainable outcomes allowing States to eventually explore the use of recycled materials.
- States discussed their asphalt overlay programs for sustainability including thickness and life expectancy. States are interested in exploring if BMD can assist in attaining the expected performance life.

SUMMARY OF CRITICAL CHALLENGES IN IMPLEMENTING BMD

State participants identified several specific challenges and themes. Overall challenges included BMD validation, database setup, variabilities, and barriers to full implementation including funding and communicating the benefits of BMD.

- **Identifying a BMD Validation Framework.** Validation of mechanical tests is needed to make sure that test results have a strong relationship to field performance, thus supporting the development of specification criteria for mix design approval and possibly production acceptance. The first step of the validation process is to review and assess the applicability of past studies relating test results to field performance. Validation was identified by many State participants as a key challenge, and several identified several questions that require additional consideration.
    - *Framework for Validation*. States raised the need to establish a BMD validation framework with clarifications on the number of validation sites needed and factors to be considered for every mechanical test.
    - *Field Performance.* Some states noted the lack of ability to relate laboratory BMD test results consistently and systematically to field pavement performance. In particular, the materials database is structured differently and is separate from the pavement management system (PMS) database; necessitating additional effort to integrate the two datasets.
    - *Barriers.* Identify and overcome the barriers, which include internal resources within the agency, multiple responsibilities, and available funding. One State noted challenges with drafting BMD-related specifications, including difficulties in engaging field staff and addressing changes made by the contractor during construction.

- **Initial Database Setup.** State participants generally noted that there are several data fields that could be useful for reporting and analysis at the completion of testing. These fields should be captured in a common database within each State, however, what those fields are and how the database is structured varied.
    - *Template and format*. State participants noted that additional guidelines, including templates and formatting needs, may be useful for initial database setup.
    - *Laboratory produced versus plant produced data*. Additional data fields should

include the source of the samples and other related information (e.g., handling protocols, aging condition, and storage time)
    - *Data collection.* Some State participants noted a need to tie their PMS with BMD fields into other existing databases, such as a database maintained by a materials group.
    - *Challenges.* Some of the challenges include effective management of the database and ability to tie materials test results to PMS and field performance.

- **Sources of Variabilities.** Over the course of discussion, several variabilities in materials and test procedures were identified that could impact the implementation of BMD. There are a number of variabilities that create some inconsistency in test results and erode confidence among contractors and agencies. State participants identified these common areas where further research and consideration for standardization could be helpful as BMD approaches gain further acceptance:
    - *Identifying the correct test, specifications, and methods.* States reported challenges over identifying useful cracking tests, specifications, and methods to define a strategic, implementable BMD. One State discussed concerns with inconsistency of test results.
    - *Sample handling and conditioning protocols*. States, in general, reported a lack of documented protocols on how to handle asphalt mixtures. It was understood that greater care and more detailed procedures would be needed for mechanical tests than volumetric properties as the former is significantly more sensitive to sample handling and conditioning. None of the states specify the lag time (i.e., how long after mixing can the specimens be compacted) and dwell time (i.e., how long after compaction can the specimens still be tested and get acceptable results) for mechanical tests.
    - *Aging Protocols*. Aging protocols vary from agency to agency. The impact of long-term oven aging (LTOA) on the test criteria is still unclear. Nonetheless, state participants acknowledged the importance of considering LTOA for BMD cracking tests when evaluating surface cracking distresses (thermal cracking, top-down cracking, etc.). One participant noted that a key challenge they were facing in their state was finalizing and adopting a new laboratory aging process for the cracking test.
        - An extended LTOA duration might not be necessary when a shorter aging duration is an acceptable indicator. A critical aging duration is sufficient to differentiate between good and poor performing asphalt mixtures.
        - Some States noted a need for cracking and durability tests that include aging.
        - The aging effect on BMD test results may be more critical for asphalt mixtures with recycled materials and additives.
        - One State noted that a standardized long-term laboratory aging process would make comparisons between agencies much easier.
    - *Production versus mix design.*
        - Variability during production at the asphalt mixture plant remains an issue for BMD testing.
        - Laboratory test results from mix design often differ from the test results on plant-produced material. One state reported instances where laboratory mix designs passed the mechanical tests criteria but failed during production.

        - How to determine the optimum lot size for BMD tests while taking into consideration the variability in test results.

- **Stripping and Moisture Damage.** Moisture damage ranges in severity from raveling to stripping of an asphalt mixture. Participating States are generally satisfied with their current testing and process to identify if a mixture is moisture susceptible. However, the following challenges were raised by the States:
    - Four of the participating States use the Hamburg Wheel Tracking Test (HWTT), with another State using a modified-Lottman test (AASHTO T 283) to evaluate the moisture damage of asphalt mixtures at the mix design stage and some at the start of production. The tensile strength ratio (TSR) has a long turnaround time to get the test results and HWTT may not be practical to use during production.
    - Some of the States have been using the HWTT for a long time. Identified challenges still include writing specifications and acceptance of changes to mix design during construction.
    - Some States only use HWTT for informational purposes only.

- **Communicating BMD Value/Telling the Story/Identifying the "Why?"** Industry and officials within State agencies may need to be convinced of the need for a change in practice. The States need to identify and "document" the need for BMD and the primary goal, determine the scope, develop a plan for phased implementation and how can BMD address the agency priorities.
    - *Process.* Communicating the importance of BMD to industry and leadership is critical for further adoption. Messaging may include that BMD gives contractors flexibility in the mix design and materials selection. States need to identify and document the "why" and the "goal" of their BMD approach. Several benefits were noted by most of the participants but the primary reason to consider BMD is to improve asphalt pavement performance and this can be accomplished through BMD by eliminating poor performing mixtures. For participating States where sustainability is a priority, this remains a key factor in communicating the value of BMD.
        - One State participant noted that having definitive proof that a BMD will perform better than traditional volumetric designs is a critically important piece of data to present to management and decision makers.
        - One State participant noted that moving towards BMD is doing "the right things for the right reasons."
    - *Gaps and Issues.*
        - Having the necessary commitment and involvement from industry toward implementation of BMD.
        - Hesitation from the upper management at the State DOT to introduce something new like BMD that may potentially increase the cost. Other hesitations from upper management includes uncertain State priority over the future role of sustainability in priority decision making.

- **Adapting Mix Designs for New Materials.** Participants discussed the need to consider the performance of asphalt mixtures based on innovation. New additives and materials need to be tested for their impact on the mechanical properties of asphalt mixtures. If new materials result in asphalt mixtures that do not meet volumetric properties (or even if they do), the volumetric mix design system is not sufficient to assess how the additives affect the mechanical properties and different standards need to be considered such as BMD.

- **Volumetric Properties Historical Usage**. During the discussion, States indicated that volumetric properties, plus asphalt binder content and gradation, play a crucial role in achieving consistency and compaction during pavement construction. However, they do not necessarily directly measure pavement quality. Voids in mineral aggregate (VMA) property is typically a mix design criterion and may not be used for acceptance purposes by several states. In general, State participants believed that the use of aggregate gradation, in-place density, and asphalt binder content can be applied in the BMD concept. Nonetheless, states emphasized that contractors may be given flexibility during mix design, but consistency during production is essential for quality control and acceptance . More assistance in the following areas would be helpful for States to implement BMD:
  - Relaxing volumetric properties including which criteria, how much, and the role they play in quality control and acceptance. Questions remain:
    - Are BMD mechanical tests enough to control consistency without volumetric properties? What other parameters can be used to control consistency?
    - Will industry and leadership confidently believe using mechanical mixture performance tests in lieu of volumetric properties given current testing technology and practices?
  - Gaps and Next Steps.
    - Messaging takes time.
    - Stakeholder engagement needed.
    - Correlation of BMD test results to field pavement performance.
    - Focus on shadow and pilot projects.

- **Adequate Resources, Staffing, and Training.** State participants noted the difficulty of implementing new practices without the necessary staff and budget. Identified needs to address this issue include:
  - *Process.*
    - Training, education, and new qualifications for staff may be needed.
    - Consider formal training workshops on new procedures.
  - *Gaps and Issues*
    - More training and staffing are needed with the implementation of BMD.
    - More documentation is needed with the implementation of BMD, including existing and intended future practices.
    - Getting contractors on board with purchasing BMD test equipment for their laboratories. One State participant highlighted specific challenges in educating contractors on BMD processes.
    - One State noted that large contractors can more easily accept and implement necessary BMD tests, while smaller contractors may face challenges in investing in new equipment and training personnel.

- **Pathway for Quality Assurance (QA) including Field Acceptance and Quality Control.** There seems to be a clear desire to move forward to using BMD principles in mix design among the States participating in this Rocky Mountain West US Peer Exchange. Challenges to acceptance are further explored below, but include:

- *Gaps and Issues:*
  - Asphalt mixtures are generally designed for the lowest cost under low-bid contracts and not necessarily for performance. How can contractors use BMD to produce cost-effective asphalt mixtures while still being competitive?
  - Who should be sampling asphalt mixtures for acceptance? Where does the responsibility lie for preparing samples and specimens? What processes are in place to retain and ensure sample security? Who should be responsible for conducting mechanical tests?
  - How to overcome industry concerns with the acceptance side of the BMD process?
  - How to handle acceptance using plant-produced asphalt mixtures and possibly based on field core samples?
  - What is the sensitivity of the BMD tests to changes in asphalt mixtures components and proportions?
  - Other considerations include interlaboratory studies and restructuring pay for asphalt mixtures.

- **Other Challenges:**
  - Coming to a consensus on different aspects of BMD whether internally between the various divisions and programs of a State DOT or externally with the industry.
  - Figuring out the emerging benefits for investing in or prioritizing the implementation of BMD for some of the participating States.
  - Competing state-level priorities on incorporating sustainability into decision making.
  - Some States noted that different climate zones through districts makes identifying appropriate tests and requiring adequate specifications a challenge.
  - Availability of multiple cracking tests without clear knowledge of the assumptions, bases, and differences among them led some of the participating States to be hesitant in selecting a BMD test for implementation.

SUMMARY OF TAKEAWAYS

(Refer to Appendix B–Survey Responses for Additional Information on Current State Practices) Participants were asked to identify their primary lessons and outcomes from participating in the peer exchange. This section provides existing efforts, future roadmaps, and State level lessons learned from the peer exchange to highlight items that various DOTs found valuable and important for their future implementation efforts.

Overall Key Takeaways

- Start by developing a plan for implementation of BMD to avoid missteps and minimize mistakes that could have been avoided in the first place.
- Document and identify the agency's "why" and relative benefits of BMD. This is particularly important for the development of BMD goals and scope and when there are competing priorities.
- Leverage existing funding sources including FHWA's pooled fund resource.
- Start validation efforts early with a documented plan.

- Where possible, provide staff training on BMD approaches and implementation methods.
- Identify ways to partner with industry during implementation to ensure buy-in. This includes refocusing on and bringing contractors and the consulting community into the discussion and decision-making processes sooner.
- Leverage existing experiences and resources from peer agencies.
- Having and inspiring confidence in moving away from volumetric properties to BMD tests is critical for BMD implementation.
- Recognize that implementation of BMD will take time and might face setbacks during the process.
- Identify industry champions to help navigate key issues and move the state of practice forward.

State Program Highlights: Existing Efforts

Arizona:

- *General observations.* Arizona is in the initial phases of BMD implementation and is exploring various cracking tests with a focus on BMD Approach A. Current RAP content is very stiff. With cracking being the primary concern, ADOT is looking for reliable cracking tests for asphalt mix design, quality control and acceptance to extend asphalt pavement lives. Currently ADOT is working on a research project with academia to identify the most appropriate/reliable cracking test method(s) for routine uses. ADOT Central lab has undertaken a variety of cracking testing for research purposes and is currently conducting the Indirect Tensile Cracking Test (IDEAL-CT) on different mixtures and investigating its use in evaluating cracking resistance of asphalt mixtures. Current challenges include those in testing validation/repeatability and a lack of reheating protocols.
- *Roadmap.* ADOT is exploring/evaluating the IDEAL-CT and will look at pilot BMD projects in coming years using Approach A. ADOT needs to identify reasons for variations in testing results and how these results can be compared and evaluated. ADOT identified a need to develop formal testing procedures and is intending to start shadow projects.
- *Lessons Learned.* ADOT highlighted the importance of maintaining communication with industry and addressing challenges including long-term aging protocols and research through university partners.

Colorado:

- *General observations.* In Colorado, asphalt mix design specifications are generally done by contractors. The State has been using HWTT for a long time and has over 150 test results for IDEAL-CT from the past couple of years. There are concerns about data quality and accuracy due to a variety of different contributing factors.
    - CDOT has not established or documented aging requirements. CDOT identified a variety of challenges including identifying the appropriate test, specifications, and methods, given the wide variety available and sometimes overlapping research efforts. CDOT has conducted significant benchmarking using both the HWTT and IDEAL-CT.

- *Roadmap.* The State is exploring the potential of leveraging sustainability initiatives at both the state and Federal levels to gather support for BMD and to use BMD as a means to evaluate new products. The State is considering utilizing Approach A and B.
- *Lessons Learned.* Colorado highlighted the importance of standardizing testing processes and heating/reheating protocols for benchmarking studies.

Idaho:

- *General observations.* Idaho has tested several different methods of implementing various mix design payment requirements including paying contractors based on their results in the late 90s. Undertook an overhaul of this approach and the QA program in 2018. The State has implemented Approach A at the mix design stage using IDEAL-CT, HWTT (1–3 mm after 50,000 passes), and established limits: although the State is exploring options to adopt Approach D. ITD has been gathering and conducting some mix performance testing for information during production since 2020. All mix designs are currently being tested for both cracking (for information only) and stripping/rutting (acceptance).
- *Roadmap.* In the short term, the State is looking at submittal of compacted specimens with mix design review for testing. Looking at better ways to communicate motivations to help make a change and identifying industry champions to move things forward.
    - The State is also looking at pilot projects in coming years using Approach D design methodology and go/no-go during test strip based on mechanical tests with a fingerprint of volumetrics for mix acceptance during production.
- *Lessons Learned.* A key lesson learned is that implementation takes time: too many changes implemented at once can cause pushback or confusion from industry and stakeholders.

Montana:

- *General observations*. Montana is a long-time user of HWTT. The State has specific control requirements for asphalt binders and has recently transitioned to AASHTO M 332 (PG 58-34H). MDOT is considering the integration of IDEAL-CT and has purchased equipment for this purpose. Currently MDOT has been collecting field asphalt mixtures and has about six months' worth of data. Research studies and initial planning started for BMD implementation. However, there are concerns regarding the consistency of the produced asphalt mixture with the use of IDEAL-CT test for acceptance.
- *Roadmap.* The State is exploring IDEAL-CT. The eventual goal is to incorporate BMD in all projects. MDOT is exploring options by relaxing some asphalt mixture specifications and allowing contractors to have a larger role in mix design by completing performance tests on final products.
    - In the short term, the State is focused on identifying projects that will be built in the next 3–4 years that would be suitable candidates for mix design pilot projects and test sections.
    - Immediate items include identifying suitable projects, opening internal communications and dialogue between materials and transportation planning group, and conducting upfront logistics preparations necessary so that any test sections are a priority. Looking at implementing Approach B, C, and maybe D.

    - The State is also considering State Transportation Innovation Council (STIC) grants for continuing collaboration.
- *Lessons Learned.* Engaging with executive levels in DOT and AASHTO for input and discussion. Refocus on and bring the contractors and consulting community into any mix design decisions earlier in the process. Focus on the plan with milestones and goals and realize small steps to implementation.

Nevada:

- *General observations*. Nevada uses the Hveem mix design with NDOT conducting all mix designs in house. Contractors are responsible for proposing the aggregate source, gradation, and asphalt binder to NDOT for mix design. NDOT is currently in the initial stages of exploring the potential implementation of BMD for dense-graded asphalt mixtures. However, NDOT implemented the BMD concept for engineered stress relief course (ESRC) asphalt mixtures designed to reduce reflective cracking in asphalt concrete overlays. The State has completed three pilot projects and one full project in different climates around the state using the ESRC. The specifications require the asphalt mixture to meet certain criteria for rutting using Hveem Stabilometer, and for cracking using the flexural bending beam fatigue and overlay tests. The design air voids for the ESRC are 0.5 to 2.5%.
    - Some contractors expressed concerns with inducing rutting in the ESRC layer under the construction equipment. The implementation of a minimum Hveem stability for the mix design mitigated this concern.
    - The State has a documented procedure on reheating protocols (60°C overnight).
    - Planning to have a benchmarking study throughout the state using IDEAL-CT for dense-graded asphalt mixtures.
- *Roadmap.* The long-term plan is to move from BMD implementation in research studies and shadow projects to eventually incorporate either Approach A or B in all projects. The State is in the process of starting a new study with the University of Nevada, Reno (UNR) to benchmark asphalt mixtures using IDEAL-CT.
- *Lessons Learned.* Nevada highlighted the importance of creating buy-in and navigating the contractor and consultant community when it comes to changes in specifications. The State has experienced push-back when proposing material specification changes from contractors, including contractor desire to have other necessary aspects relaxed.

New Mexico:

- *General observations*. The State is currently in the data collection phase. Current experience with asphalt mixtures using soft and low amount of asphalt binder have resulted in pavement failures, prompting the industry desire to transition to BMD in an attempt to address the problem. A Phase 1 study undertaken by the University of New Mexico indicated that Approach A is not feasible/applicable in the State. Accordingly, NMDOT has decided to implement Approach C.
- *Roadmap.* NMDOT is exploring Approach C with implementation actions to occur within the next three years. However, challenges arise from the state's diverse climate (4–5 distinct climate zones) and widely varying traffic volumes on roads across the state. NMDOT has initiated parallel testing at the University of New Mexico for benchmarking.

- *Lessons Learned.* New Mexico's current PMS is not integrated to include mix design considerations – the State is currently developing a plan to integrate their PMS with mix design and has hired a consultant to help with the software used.

Oregon:

- *General observations.* Oregon transitioned from in-house testing using Marshall mix designs to contractor-designed Superpave asphalt mixtures. ODOT is currently using the modified Lottman test.
    - Current major distresses experienced in the state include top-down cracking; rutting is not a major concern at this time.
    - ODOT has conducted BMD-related research projects including shadow testing for HWTT in the past 3–4 years. Handling protocols have not been established yet. ODOT incorporated five BMD test sections into paving projects in 2023.
- *Roadmap.* The intent is to incorporate more RAP for sustainability benefits while maintaining performance. Future scope includes all projects with a focus on those with high asphalt tonnage. Other relevant action items include hosting a meeting with industry to introduce BMD to industry and a technical work group while working on a draft implementation schedule.
- *Lessons Learned.* Oregon is working on further establishing protocols and encouraging buy-in and leadership with management and industry. ODOT is focused on BMD implementation and will continue to explore ways to tie low carbon material initiative funding to BMD.

Utah:

- *General observations*. UDOT has historically experienced issues with pavement longevity and is looking towards adopting BMD approaches with the benefit of longer lasting pavements. The State has been using HWTT for nearly 20 years and has institutionalized Approach A with Superpave Mix Design and HWTT verification. UDOT worked closely with CDOT during the initial implementation of the HWTT and with time they were able to enhance the test repeatability.
    - The State has experienced some difficulties incorporating BMD and is seeking guidance on issues such as incorporating innovative materials. The confidence acquired with the HWTT allowed UDOT to explore and use high polymer-modified asphalt mixtures at locations with high traffic and heavy loads. These asphalt mixtures, designed to low air void levels, exhibited very high resistance to rutting in the laboratory using the HWTT and have been performing very well in the field.
- *Roadmap.* No formal plan has been developed. UDOT is planning on proceeding with new mix design requirements through a trial-and-error approach. UDOT is planning on connecting with regional peers and contacts to implement any new pilot projects or trials. The eventual goal may be to incorporate BMD into all projects.
    - The State is in the process of conducting benchmarking using IDEAL-CT and is analyzing intermediate and cold temperature cracking criteria.
- *Lessons Learned.* By implementing HWTT and experimenting with design specifications including asphalt binder content, UDOT has learned how to approach mix design and

specifications differently: this includes relaxation of target air voids level by allowing asphalt mixtures with low design air voids.

Washington:

- *General observations.* Washington introduced HWTT in 2006 and is currently also using IDT. The State has been tracking data on HWTT and mix design for the past 10 years. Contractors submit mix designs to the State while the State does verification. WSDOT is currently exploring Approach A – moving to other Approaches may be challenging given current acceptance and potential pushback.
- *Roadmap.* Further research and implementation of BMD is needed to understand and capture the effect of various asphalt binders throughout the state. The State needs to document a reheating protocol. The current PMS is separated from the materials database and structured differently: these databases need to be integrated especially to monitor distresses and performance and identify needs for new testing.
- *Lessons Learned.* WSDOT highlighted the importance of regional communications and sidebar discussion in the peer exchange to gain insight into challenges and opportunities in BMD. The State has a renewed interest in pushing BMD framework forward and foster the push within the management group.

APPENDICES

Appendix A: Participants List

Rocky Mountain West Peer Exchange on
Balanced Mix Design
Salt Lake City, UT 84101
November 29-30, 2023

Participant List

State/Organization	Participant Name	Email
AZ	Jesús A. Sandoval-Gil	jsandoval-gil@azdot.gov
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CO	Vincent Battista	vincent.battista@state.co.us
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NV	Changlin Pan	cpan@dot.nv.gov
NM	Hashem Faidi	hashem.faidi@dot.nm.gov
NM	Kelly Montoya	kelly.montoya@dot.nm.gov
OR	Christopher Duman	christopher.L.duman@odot.oregon.gov
UT	Scott Nussbaum	snussbaum@utah.gov
UT	Howard Anderson	handerson@utah.gov
WS	Sean P. McLaughlin	McLaugS@wsdot.wa.gov
FHWA	Derek Nener-Plante	derek.nenerplante@dot.gov
FHWA	Paul C.Ziman	paul.ziman@dot.gov

Appendix B: Questionnaire

FHWA Rocky Mountains Peer Exchange

PRE-MEETING SURVEY

Prior to the FHWA peer exchange meeting, attendees were asked to complete a short survey pertaining to their agency's BMD practices. The intent of the survey was to stimulate thoughts in preparation for the meeting and to generate information to help guide the meeting discussions. Responses were received from a total of 9 agencies with a summary of the results presented below.

Respondent Information

Name	Affiliation	Email
Jesús A. Sandoval-Gil	Arizona DOT	jsandoval-gil@azdot.gov
Vincent Battista	Colorado DOT	vincent.battista@state.co.us
Mike Copeland	Idaho DOT	Michael.Copeland@itd.idaho.gov
Oak Metcalfe	Montana DOT	rmetcalfe@mt.gov
Charlie Pan	Nevada DOT	CPan@dot.nv.gov
Kelly Montoya	New Mexico DOT	Kelly.Montoya@dot.nm.gov
Christopher Duman	Oregon DOT	christopher.l.duman@odot.oregon.gov
Scott Nussbaum	Utah DOT	snussbaum@utah.gov
Howard Anderson	Utah DOT	handerson@utah.gov
Sean P. McLaughlin	Washington State DOT	McLaugS@wsdot.wa.gov

BMD Current Practice

What is the current implementation status of BMD?

Agency	Response
Arizona DOT	Still thinking/exploring.
Colorado DOT	Shadow projects, Initial Planning.
Idaho DOT	Shadow projects, Research Studies, Initial Planning, Still thinking/exploring, Other- Mix Designs are required to meet rutting/stripping thresholds. Ideal-CT is ran for information only.
Montana DOT	Research Studies, Initial Planning.
Nevada DOT	Shadow projects, Research Studies.
New Mexico DOT	Research Studies.
Oregon DOT	Pilot projects, Shadow projects, Research Studies.
Utah DOT	Research Studies, Initial Planning, Still thinking/exploring, Other - BMD approach A is institutionalized with Superpave Mix Design and Hamburg Wheel Tracker verification, IDEAL-CT research and benchmarking is underway: looking for intermediate and cold temperature cracking criteria.
Washington State DOT	Fully implemented.

What is the project scope for BMD?	
Agency	**Response**
Arizona DOT	All projects.
Colorado DOT	All projects.
Idaho DOT	All projects, Other- Unsure. Likely roadways with moderate to high traffic. Currently all mix designs are being tested for both cracking (informational) and stripping/rutting (acceptance).
Montana DOT	All projects.
Nevada DOT	All projects.
New Mexico DOT	All projects.
Oregon DOT	Projects with high asphalt tonnage.
Utah DOT	All projects.
Washington State DOT	All projects, Other.

Which BMD approaches are being considered by your State DOT?	
Agency	**Response**
Arizona DOT	Approach A.
Colorado DOT	Approach A, Approach B.
Idaho DOT	Approach D.
Montana DOT	Approach B, Approach C, Approach D.
Nevada DOT	Approach A, Approach B, Approach C.
New Mexico DOT	Approach C, Approach D.
Oregon DOT	Approach B, Approach C.
Utah DOT	Approach A, Approach B, Approach C, Other - BMD approach A is institutionalized with Superpave Mix Design and Hamburg Wheel Tracker verification. We are looking for intermediate and cold temperature cracking criteria. Work with highly modified binders and low voids mixes producing higher density pavements is being done.
Washington State DOT	Approach A.

Benchmarking Studies

Were any benchmarking studies conducted during the BMD implementation process?	
Agency	**Response**
Arizona DOT	No, On-going.
Colorado DOT	On-going.
Idaho DOT	Yes.
Montana DOT	On-going.
Nevada DOT	On-going.
New Mexico DOT	
Oregon DOT	Yes, On-going.
Utah DOT	Yes.
Washington State DOT	Yes.

Who is responsible for the conduct of benchmarking mechanical tests?	
Agency	**Response**
Arizona DOT	State DOT Lab.
Colorado DOT	State DOT Lab, Other-with the assistance of Nam Tran at NCAT.
Idaho DOT	State DOT Lab, Designated third-party lab, Other-Contractors.
Montana DOT	State DOT Lab.
Nevada DOT	State DOT Lab, Other - University
New Mexico DOT	
Oregon DOT	State DOT Lab.
Utah DOT	State DOT Lab, Other - and data purposes. Our main contractors all have the IDEAL-CT test equipment and are running tests.
Washington State DOT	State DOT Lab.

What factors are included in the benchmarking study? (mixture type, NMAS, binder type). Please note if impacts of mix design and production variables on test results are being analyzed?	
Agency	**Response**
Arizona DOT	Comparing different cracking test. Testing different mixtures with ideal-CT.
Colorado DOT	Binder type and supplier, mix type (NMAS, gyrations), % RAP, % AC, % Voids, and % VMA. Currently no analysis of production variability's impact on the results, but we do have multiple production samples from the same mix, so it may be something we can look at in the future.
Idaho DOT	All mixes are currently being tested during design by the mix design lab. ITD has been gathering and conducting some mix performance testing for information during production since 2020 (due to staffing and resource limitations this has been challenging).
Montana DOT	We are still sorting through that, but are trying to include as much data as possible to identify any trends that may be evident.
Nevada DOT	Mixture types, binder types.
New Mexico DOT	
Oregon DOT	We've been running IDEAL-CT and Hamburg tests on much of our mixtures. We categorize Gyrations, NMAS, binder type. We haven't really been running comparisons between mix design and production results.
Utah DOT	Mixture type, binder type and content, NMAS, RAP content.
Washington State DOT	Benchmark testing for Hamburg and IDT was performed on all mix designs the State Materials lab verified for 1-2 years for all classes of mix before finalizing the specifications. Mix design parameters are Class of Mix, ESAL/Gyration Level and Grade of PG Binder.

Validation Studies

Was validation of performance tests completed to assure that mechanical test results have a strong relationship to field performance?	
Agency	**Response**
Arizona DOT	On-going.
Colorado DOT	Yes.
Idaho DOT	Yes, On-going.
Montana DOT	Other: Haven't gotten that far, but that is the plan.
Nevada DOT	On-going.
New Mexico DOT	
Oregon DOT	On-going.
Utah DOT	Yes, On-going.
Washington State DOT	No.

What is the source of field performance data used for validation process?	
Agency	**Response**
Arizona DOT	Pilot projects, Other.
Colorado DOT	Pavement management system, Accelerated load facility, Test track, Research test sections.
Idaho DOT	Pavement management system, Research test sections.
Montana DOT	Pavement management system, Pilot projects, Research test sections, Other: As I mentioned, we’re not that far yet, but these are the intended sources of field performance data.
Nevada DOT	Pavement management system, Pilot projects, Research test sections.
New Mexico DOT	
Oregon DOT	Accelerated load facility, Pilot projects.
Utah DOT	Pavement management system, Research test sections, Other - For our HiMod high density work we did a demonstration project at the Wendover I-80 POE.
Washington State DOT	Pavement management system.

Application of BMD

What is the scope or applicability of BMD tests?	
Agency	**Response**
Arizona DOT	Mix design, Initial verification, Acceptance (go/no-go), Acceptance (pay factor).
Colorado DOT	Mix design, Acceptance (go/no-go), Acceptance (pay factor).
Idaho DOT	Mix design, Initial verification, Other-Initial verification for information only. Production for information only. Both have been limited by staffing and resources. We would like to pilot a go/no-go specification we have drafted in the next year.
Montana DOT	Mix design, Initial verification, Acceptance (go/no-go), Acceptance (pay factor).
Nevada DOT	Mix design, Initial verification, Acceptance (go/no-go).
New Mexico DOT	
Oregon DOT	Mix design, Initial verification.
Utah DOT	Mix design, Acceptance (go/no-go), Other - We anticipate the IDEAL-CT test to be run in the field as a go/no-go test. We are not there yet, but that is our goal. We currently have our contractors submitting their IDEAL-CT value with their submitted mix designs for information.
Washington State DOT	Mix design; Initial verification (test trip or trial plant batch) -*High RAP/RAS Designs Only

General opinions	
What are your overall comments or concerns related to the BMD process?	
Agency	**Response**
Arizona DOT	Too many cracking tests to choose from and not have standard procedure specifications. Still quite a bit variation in testing results and how these results will be compared and evaluated.
Colorado DOT	The wide variety of tests, specifications, and methods used by states to define a “balanced” mix design makes it very difficult to implement at the DOT level. There are so many different research efforts that are ongoing, some with significant overlap. It seems like there should be an almost Superpave level of national coordination for the implementation of BMD, but currently each state is left to determine the best course of action.
Idaho DOT	I think BMD is much needed to replace/augment the current Superpave methodology. The biggest hurdles right now for us is staffing, curing protocols, and tying the test results to long-term performance.
Montana DOT	My only real concern at this point is the test for cracking we chose, IDEAL-CT, may not yield consistent results. We went with that test because of its simplicity and technician familiarity with equipment, since its similar to the Marshall test apparatus. However, the results we are seeing are not consistent so identifying trends to set specification limits has been elusive so far. My hope has always been to correlate Hamburg and Disc Shaped Compact Tension (DCT) to ideal rutting test (IDEAL-RT) and IDEAL-CT, respectively, so the quicker test could be used for QA purposes in the field, with the more complex and longer-term tests used for initial mix design verification. So far, the rutting correlation appears to have potential, not so sure for the cracking correlation.
Nevada DOT	Turnaround time is important.
New Mexico DOT	
Oregon DOT	My thought is that once a long-term laboratory aging process is to be standardized, it will make comparison between Agencies much easier to do. I believe AASHTO is working on this. Everyone wants the same thing – to pay for good mix, and screen out bad mix.
Utah DOT	For IDEAL-CT: Relationship to cracking loads and stresses in our pavements for our polymer-modified binders. Possible relationships to cold-weather cracking properties? Testing correlation from lab to lab and repeatability are still a concern.
Washington State DOT	BMD approach is working well in Washington State. Ongoing BMD process and specification evaluation being monitored for relevant future changes to improve HMA performance.

What are some of the major challenges your DOT is facing?	
Agency	**Response**
Arizona DOT	Educating the local contractors, not having standard specifications, too many tests and equipment to choose from. Standardization of test procedure. Training technicians. Money for new equipment. How do you prove that BMD mix will last longer? Not having enough money to monitor test sections? How do you validate BMD design to field performance? Can you design BMD with MEPDG?
Colorado DOT	Figuring out where to set the IDEAL-CT results criteria for different mixes, how to determine what to specify to ensure adequate cracking resistance. Determining an oven aging process for IDEAL-CT samples that reflects field aging, while still being reasonable to implement in the lab for production samples. Finding a rutting test with good performance correlation that can be run on samples during production. Hamburg is currently being used to evaluate rutting susceptibility, but is primarily a stripping test and will be difficult to run in field labs during production.
Idaho DOT	Resources to take the next steps have been a big challenge. Another is general buy-in by parts of industry and parts of ITD. We would like to move forward with some pilot projects in the next year utilizing approach D design methodology and go/no-go during test strip based on mechanical tests with a finger print of volumetrics to use for mix acceptance during production.
Montana DOT	As always, time and staff. We have let our contractors know were headed down this path and from the aspect of potentially increasing the amount of RAP usage and other contractor centric benefits, our community has been supportive, however, we haven't gotten to pilot projects yet or any spec development. But having the staff and equipment to perform the tests will be the limiting factor. We already face that with our Hamburg acceptance given there are only two Hamburg devices in the state (there is a third consultant owned Hamburg, but we are questioning their results at present.) But procuring equipment will be a hurdle as will strategically placing said equipment.
Nevada DOT	Using performance tests for acceptance or for GO/NO GO decision. Keep specimen size the same as current ones (4")
New Mexico DOT	
Oregon DOT	Statewide funding for pavement is down and projected to go considerably lower in the coming years.
Utah DOT	Staffing and technician competency. Air quality. Environmental stewardship, including challenges to our well-established hydrated lime solution for moisture damage resistance.
Washington State DOT	Finalizing and adopting a new laboratory aging process for Hamburg and IDT.

BMD Performance Tests	
Primary modes of distress	
Agency	**Response**
Arizona DOT	Rutting, Fatigue cracking, Thermal or block cracking, Reflective cracking, Moisture damage.
Colorado DOT	Fatigue cracking, Thermal or block cracking, Reflective cracking.
Idaho DOT	Rutting, Fatigue cracking, Reflective cracking, Moisture damage.
Montana DOT	Rutting, Fatigue cracking, Thermal or block cracking, Reflective cracking.
Nevada DOT	Fatigue cracking, Thermal or block cracking, Reflective cracking, Moisture damage.
New Mexico DOT	Fatigue cracking, Thermal or block cracking, Reflective cracking.
Oregon DOT	Fatigue cracking, Thermal or block cracking, Reflective cracking.
Utah DOT	Rutting, Fatigue cracking, Thermal or block cracking, Reflective cracking, Moisture damage, Friction characteristics.
Washington State DOT	Rutting, Fatigue cracking, Moisture damage.

Summary of Agency Experiences with Mechanical Testing				
Arizona DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	Hamburg	Ideal-CT	IMC	–
Test Criteria (if available)	AASHTO T 324	ASTM D8225	Arizona test method 802	–
Laboratory Aging protocol or simulation	2-hour	2-hour	2-hour	–
Well-defined lag time and dwell time? Yes or No (if Yes please provide details on your process)	Lag Time = Can range anywhere between a few days and a few weeks. Dwell Time = Usually 1-2 days after specimens are compacted the tests are conducted.	Lag Time = Can range anywhere between a few days and a few weeks. Dwell Time = Usually 1-2 days after specimens are compacted the tests are conducted.	–	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	–	–	–	–

–not applicable or not available

Colorado DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	Hamburg Wheel Tracker	IDEAL-CT	Hamburg Wheel Tracker	–
Test Criteria (if available)	Max of 4mm after 10,000 passes	Still determining.	Max of 4mm after 10,000 passes.	–
Laboratory Aging protocol or simulation	No	No, but investigating options.	No	–
Well-defined lag time and dwell time? Yes or No (if Yes please provide details on your process)	No	No	No	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	–	–	–	–

–not applicable or not available

Idaho DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	AASHTO T 324	ASTM D8225	AASHTO T 324	–
Test Criteria (if available)	<10.0 mm @ 15,000	> 80 (information only at this time)	No stripping inflection point (SIP) @ 15,000	–
Laboratory Aging protocol or simulation	AASHTO R 30	AASHTO R 30	AASHTO R 30	–
Well-defined lag time and dwell time? Yes or No (if Yes, please provide details on your process)	No	No	No	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	Yes	Yes	Yes	–

–not applicable or not available

Montana DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	Hamburg	IDEAL-CT	TSR (Potentially Hamburg if certain questions are addressed, i.e., SIP calculation.)	–
Test Criteria (if available)	½" rut max after 15,000/10,000 passes for verification and production, respectively, although these may change with our implementation of MSCR	TBD. Performing LMLC evaluations of mixes now, moving to PMLC evaluation and eventually shadow projects for benchmarking.	70% ratio, min.	–
Laboratory Aging protocol or simulation	2 hours per R30 for volumetric testing (simulation of plant dwell time)	6 hours at 135C	Standard for TSR	–
Well-defined lag time and dwell time? Yes or No (if Yes, please provide details on your process)	Not defined, but ASAP in practice. Max 7 days dwell for acceptance.	Not defined	Not defined. Consultant provided.	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	Yes	–	–	–

–not applicable or not available

Nevada DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	Hveem Stability	Texas Overlay Tester Tex-248-F 7% voids, 10°C 0.018"displacement	T 283	–
Test Criteria (if available)	High Traffic =37 Medium Traffic =35 Low Traffic =30	PG64=2,000 cycle PG76=1,750 cycle Hveem Stability >18	TSR > 70% Original TS, PG76=100 psi PG64= 65 psi	–
Laboratory Aging protocol or simulation	16 hrs 60 Degree C	Short term aging	16 hrs 60 Degree C	–
Well-defined lag time and dwell time? Yes or No (if Yes, please provide details on your process)	Yes Lag time=within 24 hrs. Dwell time= 2 hrs	No	Yes, see AASHTO procedure	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	Yes	No, for Mix Design only	Yes	–

–not applicable or not available

New Mexico DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	–	–	–	–
Test Criteria (if available)	–	–	–	–
Laboratory Aging protocol or simulation	–	–	–	–
Well-defined lag time and dwell time? Yes or No (if Yes please provide details on your process)	–	–	–	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	–	–	–	–

–not applicable or not available

Oregon DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	Hamburg	IDEAL-CT	Modified Lottman/ Hamburg	–
Test Criteria (if available)	7mm @ 20,000 passes at 50C	Not chosen	80 TSR mix design No inflection point at 15,000 passes	–
Laboratory Aging protocol or simulation	R30 short term only	Long term 24 hours at 95°C		–
Well-defined lag time and dwell time? Yes or No (if Yes, please provide details on your process)	No	No	No	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	–	–	–	–

–not applicable or not available

Utah DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	T 324	ASTM D8225	T 324	–
Test Criteria (if available)	<10mm in 20K passes		<10mm in 20K passes, no stripping inflection.	–
Laboratory Aging protocol or simulation	2 Hours, R 30	2 Hours, R 30	2 Hours, R 30	–
Well-defined lag time and dwell time? Yes or No (if Yes please provide details on your process)	Lag time: Lab samples: Compact immediately. Field samples: Within 48 hours. Dwell time: Not specified, practice is to run the next day.	Lag time: Compact on the first day. Dwell time: Break on the next day (no less than 8 hours, no greater than 20 hours).	Lag time: Lab samples: Compact immediately. Field samples: Within 48 hours. Dwell time: Not specified, practice is to run the next day.	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	Yes Generally, only a mix design test.	–	Yes Generally, only a mix design test.	–

–not applicable or not available

Washington State DOT				
Item	**Rutting**	**Cracking**	**Durability/Moisture Damage**	**Other Distress**
Standard Test Method	WSDOT Hamburg Wheel-Track Testing, FOP for AASHTO T 324	WSDOT Indirect Tensile (IDT) Strength (psi) of Bituminous Materials FOP for ASTM D6931	WSDOT Hamburg Wheel-Track Testing, FOP for AASHTO T 324	–
Test Criteria (if available)	Minimum Number of Passes with no Stripping Inflection Point and Maximum Rut Depth of 10 mm at < 0.3 ESAL's - 10,000 Passes 0.3 to < 3 ESAL's - 12,500 Passes ≥ 3 ESAL's - 15,000 Passes	175 psi Maximum all Classes of Mix	See Rutting Specification	–
Laboratory Aging protocol or simulation	4 hrs at 135˚C. Currently working on new temperature and time specification for aging that reflects 5-7 years of pavement performance.	Same as Rutting	Same as Rutting	–
Well-defined lag time and dwell time? Yes or No (if Yes, please provide details on your process)	No	No	No	–
Same test used during mix design and acceptance? (if applicable) Yes or No (if No, please specify test)	No	No	No	–

–not applicable or not available