THE UNIVERSITY of TENNESSEE KNOXVILLE

Balanced Mix Design - Reality Check on QC Testing and State DOT Adoption

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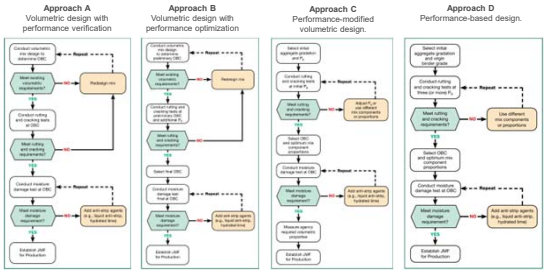
Agenda

- General terminology: BMD Approaches and Tiers
- Key aspects enabling a full implementation of mix design and QA/QC phases of BMD
- Current developments of BMD implementation
- Synthesis of state research projects on BMD
- Our own survey (2025)
- Summaries and Recommendations
- Acknowledgment
- Questions

General Terminology: Approaches and Tiers

BMD Approaches (AASHTO, MP 46-22) *Refer to **Design Methodology** and **how mechanical tests integrated** in mix design process



General Terminology: Approaches and Tiers

Reimaging BMD – Definition of BMD TIERs (Draft AASHTO Practice)

- **Tier 1 – Baseline Requirements for BMD specifications**
  - Meets selected constituent, volumetric, and mechanical test requirements for performance characteristics.
- **Tier 2 – Greater Flexibility**
  - Allows relaxation of certain constituent and volumetric requirements to provide more flexibility in material selection and mix adjustments.
  - Emphasizes mechanical testing while reducing reliance on specific constituent and volumetric parameters.
- **Tier 3 – Performance-Driven Design**
  - MINIMIZES detailed constituent and volumetric requirements, with primary reliance on performance-based material & design optimization, and mechanical testing to validate mixture performance.

*Refer to mixture **Specification Level** and **How Much flexibility** is allowed in constituents and volumetric properties

- Certain constituents and volumetric properties may be designated as **report-only** for informational and quality assurance (QA) purposes.

4 • *Reimaging BMD – New AASHTO Standard Overview, A workshop presentation, 2025. Balanced Mix Design Implementation Working Group (MIG)*

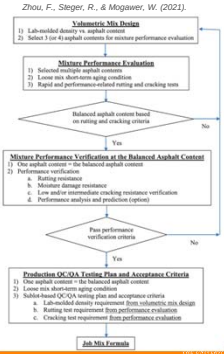
Key Aspects Enabling a Full Implementation of Mix Design and QA/QC

Phases of BMD

- **Selection of performance tests** for Design & QA/QC
- **Aging protocols** for rutting and cracking tests for Mix Design & QA/QC phases
- **Specification/criteria** of performance tests for Mix Design & QA/QC phase
- Whether **volumetric and constitution parameters** as **specifications** or **report-only** in design and QA/QC phases.

The study will focus on these key aspects

Zhou, F., Sieger, R., & Mogawer, W. (2021).



Current Developments of Balanced Mix Design

BMD approaches

2023-2024 DOTs peer exchanges

2025 NAPA Survey

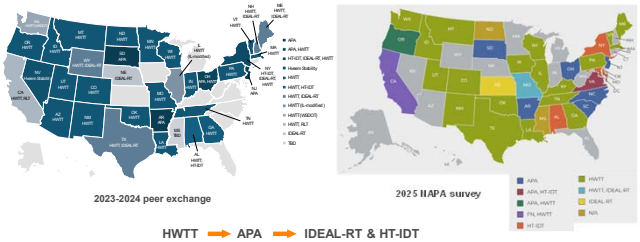
Approach	State
Information retrieved from **the peer exchange surveys in 2023 (peer exchange, 2023)**	
Approach A	**Alabama**, **Louisiana**, Pennsylvania, Arizona, Washington, Illinois, Michigan, Minnesota, South Dakota
Approach A & B	Massachusetts, New Hampshire, New Jersey, Colorado, Indiana, Wyoming,
Approach A, B & C	Vermont, Nevada, Utah, Ohio
Approach A & C	New York
Approach B	Missouri, North Dakota
Approach B & C	**Texas**, Oregon
Approach B, C & D	Montana
Approach B & D	**Oklahoma**
Approach C	**Georgia**, Wisconsin, California
Approach C & D	**Arkansas**
Approach D	**Tennessee**, Idaho
TBD	**Mississippi**, Maine, Nebraska, Connecticut
Information retrieved from **NAPA website 2025 (NAPA, 2025).**	
Approach A	**Texas**, **Louisiana**, **Kentucky**, Wisconsin, Illinois, New York, Vermont
Approach B	**Virginia**, **Oklahoma**, Missouri
Approach C	**Alabama**, California
Approach D	-
Approach A&B	New Jersey
Pre-implementation (**22 states**)	**Arkansas**, **Mississippi**, **Tennessee**, **North Carolina**, **South Carolina**, **Georgia**, Washington, Oregon, Idaho, Montana, North Dakota, South Dakota, Utah, Colorado, New Mexico, Iowa, Ohio, Kansas, Pennsylvania, Maine, Massachusetts, Maryland

Note: The member states of the Southern Association of State Highway and Transportation Officials (SASHTO) or SEAUPG are highlighted in **bold**.

6 *Southeast, Midwest, North Central, Northeast, Rock Mountain West, Mid-Atlantic, Mega states Peer Exchange on BMD, 2023-2024*

Current Developments of Balanced Mix Design

Anticipated adoption of **RUTTING** performance tests



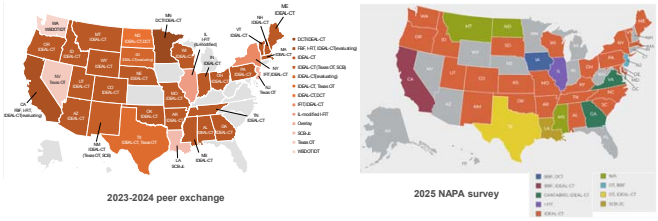
2023-2024 peer exchange

2025 NAPA survey

HWTT → APA → IDEAL-RT & HT-IDT

Current Developments of Balanced Mix Design

Anticipated adoption of **CRACK** performance tests



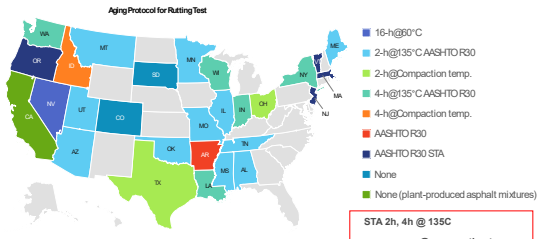
2023-2024 peer exchange

2025 NAPA survey

IDEAL-CT → I-FIT, OT, SCB

Current Developments of Balanced Mix Design

U.S. map of **AGING** protocol for RUTTING performance tests

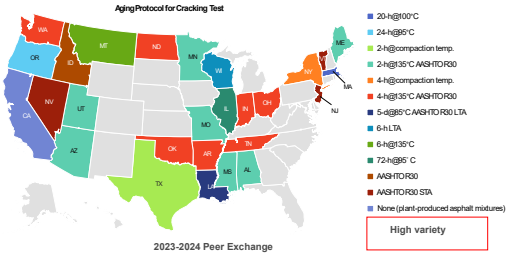


2023-2024 Peer Exchange

STA 2h, 4h @ 135C
or @ compaction temp.

Current Developments of Balanced Mix Design

U.S. map of **AGING** protocol for CRACK performance tests



2023-2024 Peer Exchange

High variety

State Research Projects on BMD

State-Based BMD Research Landscape (131 studies including projects, journal papers & dissertations)

Main categories	Subsets of detailed topics
Performance-based tests Total study: 85 States: 35	Performance-based tests – Cracking (Thermal cracking, Low temp., and intermediate temp) – Rutting – Moisture susceptibility – Friction – Surrogate tests/ Alternative tests/ Rapid tests Performance-based tests specification: – Preliminary threshold criteria – Property-temperature relationships – Performance Space Diagram – Surrogate tests indices – Performance thresholds refinement
Specification verification & Correlation Studies: 17 States: 10	– Correlation between performance test results and volumetric parameters – Field performance data correlations – Lab-to-field aging correlation – Field core testing
Volumetrics and constituents Studies: 13 States: 10	– Binder source and content – Asphalt content – Corrected Optimum Asphalt Content – Gradation and volumetric adjustment – Lab-molded density – Balanced Mix Design Gyrations Index-volumetrics relationships
Aggregate Studies: 4 States: 4	– Relatively soft aggregate – Max. amount of sandstone aggregates – Alternative local aggregate – Fines quality – Aggregate and binder compatibility

Main categories	Subsets of detailed topics
Variability and Sensitivity Studies: 30 States: 16	– Production variation between sublots, sources, and mix batches – PMLC, LMLC, PMFC, FMLC, FMFC, Entity, producer, and district variation – Within-lab and Interlaboratory study, – Laboratory repeatability – Analysis of Variance (ANOVA) – Operating parameters, – Key variability statistics
Benchmarking Studies: 9 States: 7	– Performance tests, – Volumetric benchmarks, – Different aging protocols, – Different BMD approaches – BMD vs. Superpave volumetric approach
RAP/RAS Studies: 18 States: 13	– High RAP content (50 or 70 percent) – Cold-recycling processes – Minimum virgin binder content
Modifications, additives Studies: 13 States: 8	– SBS modified, High polymer modified – Fiber reinforced materials – Recycling agent & additives, Rejuvenating asphalt emulsions – Tall oil and waste vegetable oil – Softener-type Modifiers, Bio-based Modifiers – Recycled plastic, GTR – Triglycerides and Fatty Acids (TF) – Antioxidants, Zinc diethyldithiocarbamate (ZnDEC)

State Research Projects on BMD

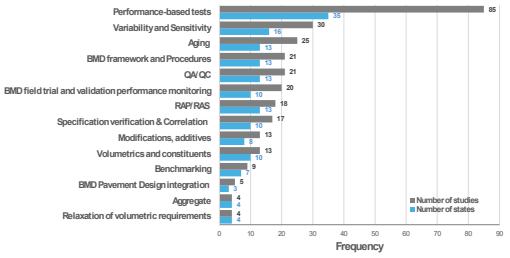
State-Based BMD Research Landscape (131 studies including projects, journal papers & dissertations)

Main categories	Subsets of detailed topics
Relaxation of volumetric requirements Studies: 4 States: 4	– Withdrawing the regressed air voids design requirement, – Gradation adjustment – Current tolerance limits for binder content – In-place density on performance
Aging Studies: 25 States: 13	– Reheating effects and isolation – Short-term and long-term aging – Scaling factor – Effects of silo storage – Lab-to-field aging correlation – Aging conditions from plant to lay down and field cores
QA/QC Studies: 21 States: 13	– Plant-produced mixtures – Mix design verification – Performance-related QA/QC – Non-destructive QA method (Ultrasonic Pulse Velocity) – Balancing high lab-molded density values at plant production – A coherent BMD/QC/QA framework

Main categories	Subsets of detailed topics
BMD field trial & validation performance monitoring Studies: 20 States: 10	– Pilot projects – Shadow projects – Test track – Field validation of BMD test criteria – Field performance relationship – Field vs. Laboratory Performance – Calibration with 20-year projected distresses – PMS
BMD framework and Procedures Studies: 21 States: 13	– Case Studies/literature review – White paper – Roadmap – Training and certification – BMD framework and Procedures, – Survey on DOTs Implementation – A coherent BMD/QC/QA framework – Pay Assessment Schedules – Cost-effective analysis
BMD Pavement Design integration Studies: 5 States: 3	– Mechanistic-Empirical (ME) design/ FlexPAVE – Integration of Mix Design and Structural Design – Cost-effective analysis

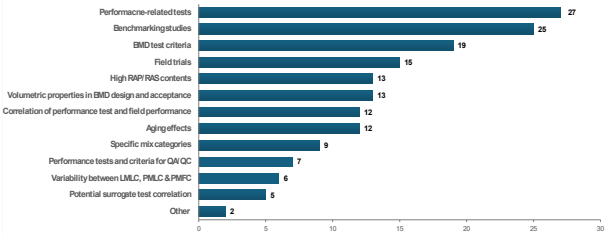
State Research Projects on BMD

State-Based BMD Research Landscape (131 studies including projects, journal papers & dissertations)



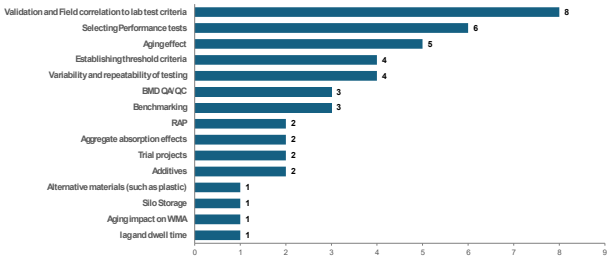
Our Own Survey (2025)

- The survey feedback from **thirty-seven (37) state DOTs.**
- Primary **Current** Focus on Topics Related to BMD



Our Own Survey (2025)

- **Future** Research and Technical Priorities



Our Own Survey (2025)

- *The **EXAMPLES** of specific research topics DOT agencies prioritized for **further research related to BMD***

Topics	State
Field trial projects & field validation	– **Alabama (validation section)** – Ohio (trial projects, field correlation), – Vermont (validation of thresholds, long-term oven aging) – South Dakota (field correlation) – Minnesota (field performance) – Oregon (field trials)
Performance testing focus	– **Mississippi (best performance tests)** – **Tennessee (QA/QC)** – **Florida (benchmarking)** – **Alabama (benchmarking)** – **Louisiana (surrogate tests, production testing)** – Missouri (variability, Hamburg SIP, absorptive aggregates) – New Jersey (quick tests for QC, repeatability, long-term correlation) – North Carolina (IDEAL-RT)

Topics	State
Aging studies	– **Oklahoma (aging, long-term storage, additives, silo storage)** – **Louisiana (Aging relationships)** – Kansas (aging, lag/dwell time) – North Dakota (aging with high-absorption aggregates) – Utah (warm mix and RAP impact on aging) – Vermont (long-term oven aging)
RAP, Recycled Materials, and additives	– **Oklahoma (additives),** – **Hawaii (alternative materials like plastic),** – Oregon (high RAP content), – Utah (RAP variability). – Colorado (lime vs. liquid antistrip)
Variability & repeatability	– **Virginia (COV, D2S for bias/precision),** – **Florida (Variability between plant sampling vs from the paver auger)** – New Jersey (accuracy, repeatability).

Our Own Survey (2025)

- ***Status of BMD implementation***

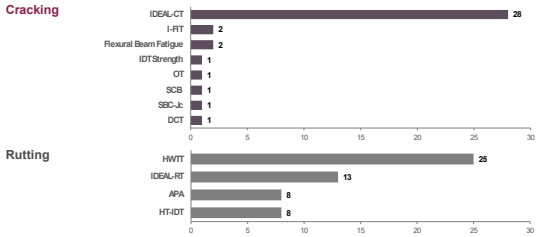
State	The status of BMD implementation in your state.
Alabama	**Pilot projects**
Hawaii	**pilot**
Mississippi	Still only **benchmarking** mix designs
North Carolina	**Surface mixes** only at this time
Virginia	**All Surface mix**
Tennessee	**Benchmarking** dense graded surface mixture and **validation test sections**
Louisiana	**All wearing and binder course mixtures**
Oklahoma	**All projects**
Georgia	We have implemented a number of performance tests related to BMD in conjunction with the **COAC process**, **but haven't officially called it BMD.**
Florida	At this point, FDOT is **not prioritizing** the implementation of BMD.
West Virginia	We are not yet to this point.

- ***SASHTO or SEAUPG states,***
*No details provided: **Arkansas, South Carolina, Kentucky, Texas***

State	The scope of BMD implementation in your state.
Colorado	**Pilot Projects**
Illinois	**All Projects** – Implemented
Indiana	**none**. Based on our interlaboratory study, the inconsistency and variability between labs with the same material is of great concern.
Kansas	We have **not set a date for implementation**. We are really struggling with how much to account for short-term aging during production without causing more variability in test results (between parties testing and between projects).
Minnesota	**Benchmarking**
Missouri	**Pilot Projects** on SuperPave mixtures
Nebraska	We do not plan to implement for QA/QC. We will use to support or current system and help with our specs and designs.
New Jersey	Use is for **specific mixes on medium and high traffic level projects**
North Dakota	As of now unsure. Hoping to have on all, but unsure on starting point. More research needed.
Ohio	Not sure what is being asked. The ultimate goal is to apply this to everything and being able to **reduce mix types** (we currently utilize Marshall and SuperPave) and **increase RAP responsibility**.
Oregon	Currently **pilot projects**.
South Dakota	Specific mix category (mostly mainline mixes).
Utah	We are using what we call HiMod high density asphalt all over our state. This mix uses a PG 76-34 highly modified binder with the mix designed at 1percent voids, 50 gyrations (near zero voids at 75 gyrations). The high binder content mixture can be placed in thick or thin layers and has proven to produce a high performance pavement at a cheaper cost than SMA. We are now also allowing up to 15 percent RAP in our surface courses. Previously, RAP was only allowed in the lower HMA layers.
Vermont	All projects at this time.
Wyoming	No implementation

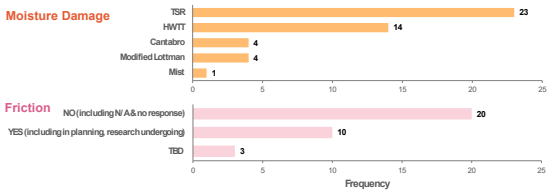
Our Own Survey (2025)

- **Performance Tests** included (or plan to include) in DOTs BMD implementation.



Our Own Survey (2025)

- Performance tests included (or plan to include) in DOTs BMD implementation.



Our Own Survey (2025)

- Performance tests must account for practical considerations such as **testing capacity**, **duration**, and **the effectiveness of reflecting actual mixture performance**.
  - The **PERFORMANCE TEST SETS** during mix design and production QC/QA.

Use the SAME test set?	State	details
YES	Nebraska,	**Too early to accurately answer**.
	New Jersey	**Mix Design criteria is generally stricter** because of the variability of mix during production
	Illinois	**Long-Term Aging for I-FIT is done on surface course**, the LTA requirement for dense graded mixes is **5.0 in design but is 4.0 in production** which gives Contractors a buffer.
	Virginia, **North Carolina**, **Florida**, **Alabama**, Maine, Indiana, Colorado, Oregon	These states responded a consistency between design and QC/QA with no further information provided.
Not specified	**West Virginia**, **Arkansas**, **Hawaii**, **South Carolina**, **Kentucky**, Arizona, New Mexico, Connecticut, Rhode Island, Idaho	Unknown / Not specified / Still developing approach.

Use the SAME test set?	State	Details
NO / Partially	**Oklahoma**	– **HWTT is currently only used during design**, it will be potentially implemented for field testing in the future
	Georgia	– GDOT uses AC content, gradation, in-place air voids, and profile smoothness for acceptance. – For mix designs performance testing. Hamburg testing number of cycles is dependent on mix type and binder type.
	Tennessee	– **Ideal CT would be used for both**, but **HWTT would most likely be design only** with **Ideal RT or HT-IDT** being apart of QA/QC for expedient results.
	Louisiana	YES and NO. **HWT for design and production**, SCB-jc design; **no production cracking test**. Looking at modified procedures and/or IDEAL for production testing.
	Missouri	– Limit the Hamburg to 9.5 mm maximum due to production variability – With state specification provided
	South Dakota	– **Only at mix design**. – Only have thresholds for the APA and TSR tests. Still benchmarking for the IDEAL-CT.
	Vermont	**HWTT is likely staying as a mix design qualification test** due to test duration and amount of specimen preparation involved, and **IDEAL-RT would (at the bare minimum) be done during production QC/QA testing** should we find that it is an **appropriate surrogate**. **IDEAL-CT** would remain as the primary cracking test for both mix design qualification, and production QC/QA testing.
	Utah	– While most of our work is currently in the mix design phase, where practical, we would like to move some of that to be included with acceptance testing. Considerations include time for results, test repeatability, etc.
	Ohio	– **HWTT takes to long for QA** – I'm going to assume the **IDEAL-CT STOA versus reheat from plant produced will have different results**. Will know more once we start getting field performance data.
	Kansas	Right now we are **only looking at plant produced mixes** for rutting and cracking tests.
	North Dakota	– Tests have either been ran at various mix design labs from consultants or at our main lab within the NDDOT. There has been no field testing conducted at testing labs on site (outside of our test trip project where NCAT brought their mobile lab). – **Not enough research has been conducted**. Assuming issues will come from aging, specimen prep, and aggregate properties.
	Mississippi, Minnesota, Wyoming,	– These states responded different sets of tests between design and QC/QA with **no further information provided**.

Our Own Survey (2025)

- The **Criteria and Thresholds** of performance tests for mix **Design** and production **QC/QA**.

State	Criteria and thresholds (Design)	Criteria and thresholds (Acceptance & QA)
Virginia	– IDEAL-CT =70, – APA <8mm, – Cantabro < 7.5% loss, – TSR > 80%	-
Georgia	– Rutting less than 12.5mm. (HWTT, AASHTO T 324) – Moisture damage requires .80 retained strength with minimum 60 psi for all specimens.	N/A
West Virginia	Design: TBD	QA: TBD
Oklahoma	– Cracking: CT-Index = 100 for surface and 60 for intermediate and base – Rutting: HWTT 12.5 mm	Just Ideal-CT has been considered and evaluated
North Carolina	APA jr, 64C 8000 cycles	-
Alabama	– Cracking: 50, 75, 100 depending on the ESAL range – Rutting: 20 psi (HOT-IDT) – TSR: 0.80 minimum	-
Louisiana	– Cracking: Low ADT - 0.5, High ADT - 0.6 kj/m2 – Rutting: Low ADT <10mm, High ADT < 6mm @ 20k; no SIP. – TSR: < 80%	Same or N/A
No details provided: – **Arkansas, Mississippi, Tennessee, Hawaii, South Carolina, Kentucky, Florida**		

Our Own Survey (2025)

State	Criteria and thresholds (Design)	Criteria and thresholds (Acceptance & QA)
Nebraska	None determined yet	None determined yet
Ohio	**IDEAL-CT STOA** of 80, for a 12.5 mm intermediate it's 70 (wasn't part of research), intermediate and base (two base mixes tested) is 60. Have used them on pilot projects.	-
Indiana	No criteria set.	
Missouri	https://modotgov.sharepoint.com/sites/DE/_layouts/15/Doc.aspx?sourcedoc=%7BB7B06F63-B9B3-44FD-BAFD-D268B0866B50A%7D&file=JSP2401.docx&action=default&mobileredirect=true	Same
Utah	It depends on the product and application: **Hamburg** with a temperature dependent on the modified asphalt binder grade. **Polishing value** is a minimum of 31, but only for surface courses. Our highly-modified asphalt specification has different requirements than our dense-graded asphalt mix. **IDEAL-CT**: No threshold established yet. **Lottman Test**: we use hydrated lime in all our mixtures and test occasionally for information only.	-
South Dakota	**APA** maximum rutting is 5-8 mm at mix design, depending on the mix type. Minimum **TSR** is 80%, but the requirement is waived if 1.00% hydrated lime is added to the mix.	-
New Jersey	– HPTO & BRIC: **APA**, **Overlay**, **TSR** – BRBC: **APA**, **FBF**, and **TSR** – BDWSC: **APA**, **FBF**, and **TSR**	– **TSR** not done during production – BRIC: **APA** and **Overlay** – High RAP: See Standard Specifications
Vermont	– **CT-Index** minimums of 45 (3/4" NMAS Type IIS mixes), 70 (1/2" NMAS Type IIIS mixes), and 85 (3/8" NMAS Type IVS mixes) – **Hamburg**: Maximum 12.5 mm (1/2") rut depth after 20,000 passes Moisture damage: Stripping inflection point (SIP) no less than 15,000 passes	NO
Alaska	For design: **APA** rutting threshold is 3 mm (at 105 F; 8,000 cycles).	NONE
Maine	**CT** >150, **RT**>55, **HWT** > 20,000 passes; **SIP**>15,000 passes	
Kansas	**TSR**=80%	-
Oregon	Rutting (**Hamburg**): 5 mm (100 gyration mixes), 7 mm (80 gyration mixes). Moisture Damage (**TSR**): 80 min.	-
North Dakota	None set yet. Still benchmarking and relating to field performance.	N/A
Illinois	**Tensile Strength** and **TSR** requirements **Hamburg** Wheel Test requirements **I-FIT**	Links to the specs attached above
No details provided: Colorado, Wyoming, Arizona, New Mexico, Minnesota, Connecticut, Rhode Island, Idaho		

Our Own Survey (2025)

- **Aging Protocols** for performance tests for **Mix Design** and production **QC/QA**.

State	Aging Protocols		Same aging for design & QA/QC?
Virginia	R	2-hour short term aging	YES
	C	4-hour short term aging, 6-hour long term aging at compaction temperature	
	M	NONE	
Georgia	R	AASHTO T 324	OTHER: Don't require it for acceptance.
	C	ASTM D8225	
	M	AASHTO T 283	
Oklahoma	R	4 hours at 135C	NO. we evaluated reheating the specimen and also hot compaction, we recommend the re-heating to compaction temperature for a maximum of 2 hours
	C	4 hours at 135C	
	M	2 hours at 135C	
Mississippi	R, C, & M	2 hour aging at compaction temp	-
Tennessee	R	2 hours at at 135C as loose mix	NO No STOA when using plant mix
	C	4 hours at at 135C as loose mix	
	M	2 hours at at 135C as loose mix	
Alabama	R, C, & M	2-hr	YES
Louisiana	R	2hr	OTHER: verification yes. QC looking at utilizing unaged with shift factor for Jc.
	C	5day 85C	
	M	modified lottman protocol	
TBD / Not provided / undetermined at this time / under review: West Virginia, Arkansas, North Carolina, Hawaii, South Carolina, Kentucky, Florida			

Our Own Survey (2025)

- Presence of **Lag/Dwell Time Requirements**

Lag/Dwell Time Requirements	State
YES (explicit requirement exists)	– **Nebraska**: Max lag time = 7 days, dwell time = within 24h. For QA/QC, reheating may be mandated. – **Missouri**: Plant-compacted only; minimum lag time; maximum dwell time = 2 weeks. – **Kansas**: Within 96h of collection, reheat & age at 275°F (135°C) for 90–120 min; compact within 120 min; cool 1–2h; condition in water bath (77°F, 60±5 min); test within 5 min of removal. – **Oregon**: Not currently, but requirement will likely be specified in future. – **Ohio**: For IDEAL-CT STOA mix design, required dwell time ≥16h.
NO (no requirement specified)	– **Alabama, Louisiana, Mississippi, Oklahoma, North Carolina, Virginia, Indiana, South Dakota, New Jersey, Wyoming, Vermont, North Dakota,**
OTHER / Conditional / Under Evaluation	– **Georgia**: follow established procedures, no explicit requirement – **Tennessee**: No requirement currently; following ongoing research – **Hawaii**: under review – **Arkansas**, New Mexico, Arizona, Minnesota: not specified – **West Virginia**: TBD – **Florida**: not specified – **Illinois**: Recommend I-FIT specimens be tested within 3 weeks of production. – **Utah**: samples made day 1, tested day 2 – **Maine**: still being determined – **Alaska**, Colorado: N/A

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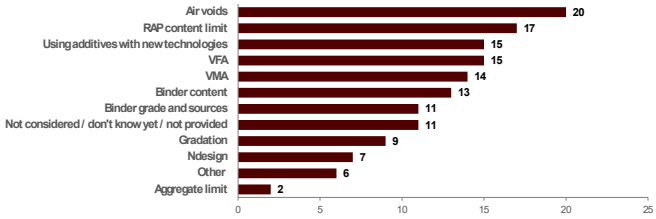
Our Own Survey (2025)

- Potential **adjustments or relaxations** to volumetric and constituent requirements.



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Our Own Survey (2025)

- The feedback on **Compaction Efforts**.

State	Feedback
Adopted Reductions/Considering Adjustments	
West Virginia	reported TBD.
Louisiana	reduced as part of BMD spec.
Nebraska	reduced compaction as early as 2008, with most mixes now designed at 50–60 gyrations.
Missouri	**lowered** N_{design}
Utah	explicitly changed N_{design} to 50 gyrations
Vermont	actively discussing eliminating high N_{design} values (80 gyrations) altogether, citing BMD research and compaction issues.
Ohio	N_{design} will eventually be phased out entirely under full BMD implementation.
North Dakota	anticipates lowering compaction; currently most mixes are still at 75 gyrations.
Illinois	marked as TBD, suggesting ongoing review.
No Changes / Not Currently	
Virginia, Georgia, North Carolina, Alabama, Oklahoma, Oregon, Kansas, Maine.	
No information provided	
Mississippi, Tennessee, Hawaii, Florida, Arkansas, Minnesota, New Mexico, Alaska, Arizona	

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Our Own Survey (2025)

- **Primary challenges** that your DOT agency encounters in implementing BMD

State	The most commonly heard feedback or concerns from contractors
Virginia	**Initial cost** of equipment was high; **time** requirements restricting
Georgia	**Costs** and **validation** of specified tolerances (criteria?).
Oklahoma	concern about the **changes to pay factors, design methods, and equipment**
Mississippi	equipment investment
Tennessee	Equipment investment
Alabama	**Increased testing times** and how do **pay factors** work with BMD
Louisiana	**time and equipment**

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Different stages in general of BMD implementation

No Implementation / Not Planned yet

West Virginia, Florida, Arkansas, Nebraska, Indiana, Wyoming, Kansas (uncertain), **North Dakota** (unsure), and **New Mexico**.

Reasons often include concerns over variability, lack of clear guidance, or no plans for QA/QC use.

Benchmarking / Research / Early Evaluation

Mississippi, Minnesota, Indiana, Kansas.

Activities mainly involve benchmarking studies, and inter-lab variability studies.

Pilot Projects / Validation Field Projects

Hawaii (pilot), **Alabama** (pilot), **Tennessee** (validation test sections), **Missouri, Colorado, Oregon, South Dakota,**

These states focus on validation test sections or pilot trials.

Full Implementation/ Limited Mix Types

Oklahoma (all projects), **Louisiana** (all wearing and binder course mixtures), **Virginia** (All surface mix), **North Carolina** (surface mixes), **Illinois** (all projects, fully implemented), **New Jersey** (medium/high traffic mixes), and **Vermont** (all projects).

These states are applying BMD on selected mix types, traffic levels or nearly all projects.

Unique Approaches or Modified Practices

Georgia integrates performance tests in the COAC process without formally calling it BMD.

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Summaries

BMD Implementation Status

- Most states remain in **pre-implementation**, verifying BMD methodologies.
- Rather than full "true" BMD adoption, agencies mainly apply **Approach A & B**(NAPA, 2025).
- **High variety** of BMD Implementation Status.

Aging Protocols

- Short-term aging (rutting): **Most states use AASHTO R30 (2–4 h @ 135 °C);** some use **plant mix without STOA**.
- Cracking-test aging: Highly variable — from **reheating**, **2–4 h to 72 h @ 95 °C or 5 days @ 85 °C.**
- Some states test **plant-produced specimens without additional oven aging**.
- Overall: **No unified standard**.

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Summaries

BMD Testing Between Design and QC/QA

- Several states limit performance testing to the mix design phase or selectively apply tests in QC/QA.
- An emerging trend shows longer tests (HWTT) are retained for mix design, while faster, more repeatable tests (IDEAL-CT/RT, HT-IDT) are increasingly used for QC/QA.
- **Examples**:
  - **OK** and **Ohio** exclude HWTT from QA/QC due to its lengthy duration,
  - States such as **GA**, **MI**, **TN**, **UT**, **SD**, and **KS** adopt partial approaches, using faster tests like IDEAL-CT or IDEAL-RT for QC/QA while reserving HWTT (more resource-intensive) for design.
- Overall insight: States balance consistency vs practicality, aiming to align performance verification with feasible production testing.

The criteria and thresholds for mix design and QC/QA.

- Compared to the mix design stage, far fewer states have re-defined QA/QC performance thresholds.

Recommendations for Future Work

Establish consensus guidance from **highly focused research areas**

- *Cracking (IDEAL-CT) and rutting (HWTT, IDEAL-RT) performance tests*

Implement **Acceptance Criteria with Variability Considerations**

- *Develop coefficient-of-variation (COV)–based acceptance limits and risk-balanced pay schedules*

A Practical Long-Term Aging (**LTA**) Protocol for Cracking test

- *Bridge the gaps between short-term (STA), long-term (LTA) aging, and field aging conditions*

Incorporate a **Friction** criterion

Develop Feasible QA/QC Guidelines

- Recognizing these operational constraints: **conditioning requirements, turnaround time, testing frequency, available testing capacity, and staffing resources**.

Stepwise Volumetric Relaxation Framework

- Progressive adoption of volumetric flexibility should occur only after core topics: **performance test specifications, validated aging protocols, & QA/QC procedures**, are established to ensure reliability and consistency.

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Questions & Comments?