Balanced Mix Design (BMD) Peer Exchange: Summary of Findings and Challenges to Implementation

U.S. Department of Transportation
Federal Highway Administration

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NEAUPG
October 25, 2023

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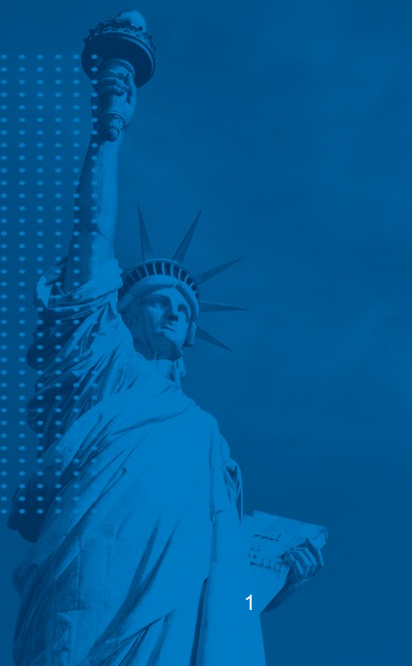

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Acknowledgements

- Tim Aschenbrener (FHWA) and Elie Hajj (University Nevada, Reno) for their work on BMD under the FHWA-UNR Co-Op, for which most of this information was generated.
  - DDIAPT, Tasks C.1.4, C.1.7, & C.1.8.
  - The content in this presentation is derived in part from work under cooperative agreement No. 693JJ31850010. The U.S. Government assumes no liability for the use of the information.

Abbreviations and Acronyms

- AASHTO – American Association of State Highway and Transportation Officials
- ABR: Asphalt binder replacement
- AC: Asphalt content
- ALF: Accelerated loading facility
- AQC: Acceptance quality characteristic
- ASTM: American Society for Testing and Materials
- BMD: Balanced Mix Design
- BRIC: Binder-rich intermediate course
- Caltrans: California DOT
- CT_{index}: Cracking index
- DOT: Department of transportation
- ESAL: Equivalent single axle load
- FHWA: Federal Highway Administration
- FI: Flexibility Index
- HPTO: High performance thin overlay
- HWTT: Hamburg Wheel Tracking Test
- IDEAL-CT: Ideal cracking test
- IDOT: Illinois DOT
- I-FIT: Illinois Flexibility Test
- JMF: Job mix formula
- LaDOTD: Louisiana Department of Transportation and Development
- LPLC: Lab-produced lab-compacted
- MaineDOT: Maine DOT
- MPL: Material producer list
- NCAT: National Center for Asphalt Technology
- N_{design}: Design gyrations
- NJDOT: New Jersey DOT
- NMAS: Nominal maximum aggregate size
- OT: Overlay Test
- P_b: Percent of asphalt binder in mixture
- PG: Performance grade
- PMS: Pavement management system
- PPLC: Plant-produced lab-compacted
- QA: Quality assurance
- RAP: Reclaimed asphalt pavement
- RAS: Reclaimed asphalt shingles
- RBR: Reclaimed binder ratio
- SGC: Superpave gyratory compactor
- SIP: Stripping inflection point
- SMA: Stone matrix asphalt
- TSR: Tensile strength ratio
- TxDOT: Texas DOT
- UNR: University of Nevada, Reno
- VDOT: Virginia DOT
- VFA: Voids filled with asphalt
- VMA: Voids in the mineral aggregate

What do we want to get out of this?

Hear challenges of Balanced Mix Design implementation as heard from State DOT's across the country

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Background

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Definitions

What is BMD?

- AASHTO PP 105-20: "*BMD is an asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate, and location within the pavement structure*."

TRB's *Transportation Research Circular E-C280: Glossary of Terms for Balanced Design of Asphalt Mixtures* provides a reference document for usage of Balanced Mix Design terminology by the asphalt mixtures community in the United States.

Design "philosophy" used to optimize the mix performance against distresses pertinent to the climate & traffic specific to the region where it will be placed.

Mechanical Tests for BMD

- Rutting Tests
- Cracking Tests
- Moisture Damage Tests
- Frictional Characteristic Tests
- Others?

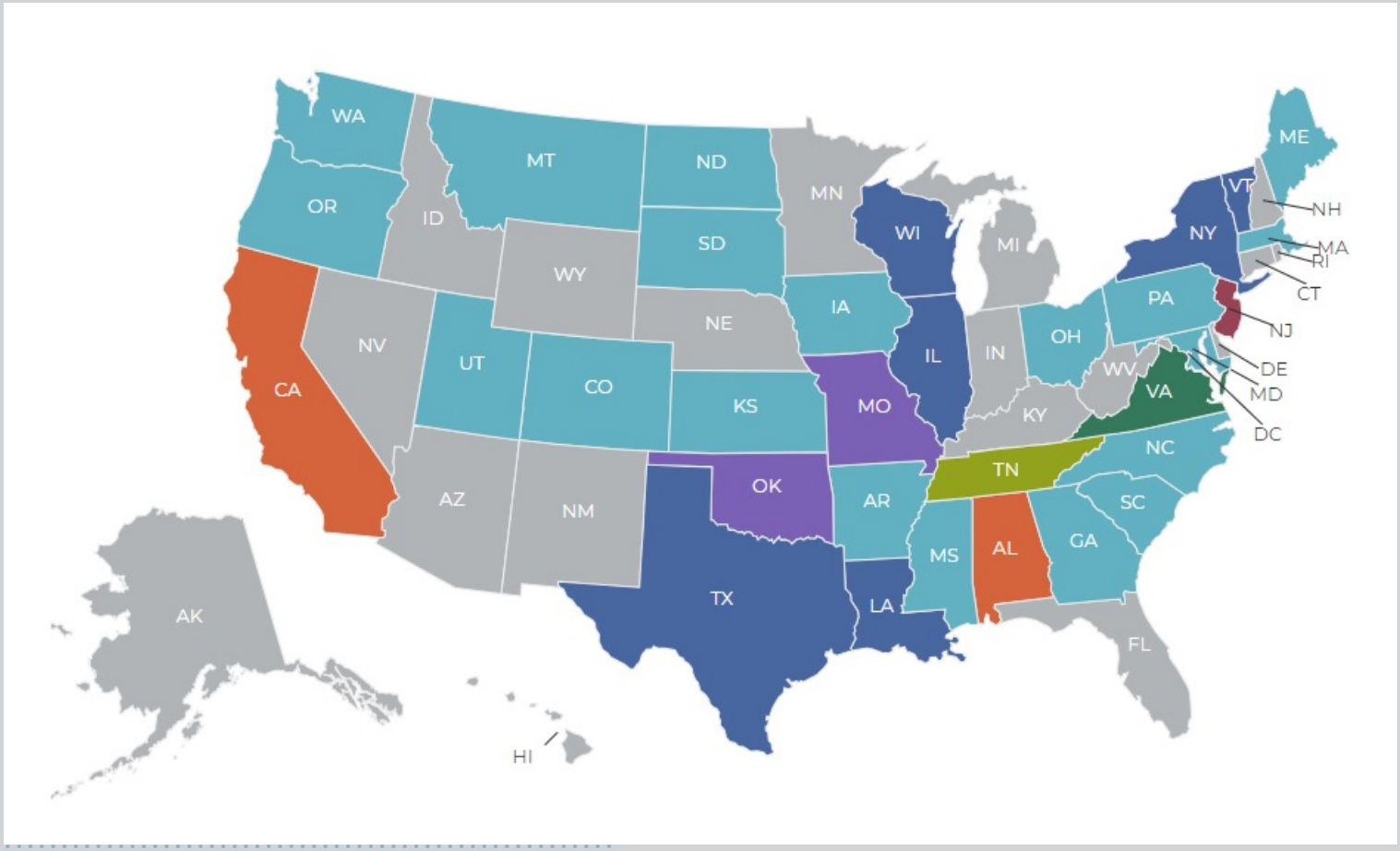
Source: NCAT

Source: NCAT

Source: James Musselman

Source: NCAT

Numerous States Moving to BMD



- APPROACH A - VOLUMETRIC DESIGN WITH PERFORMANCE VERIFICATION
- APPROACH A AND B
- APPROACH A AND D
- APPROACH B - VOLUMETRIC DESIGN WITH PERFORMANCE OPTIMIZATION
- APPROACH C - PERFORMANCE-MODIFIED VOLUMETRIC DESIGN
- APPROACH D - PERFORMANCE DESIGN
- PRE-IMPLEMENTATION

Source: NAPA
https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide/implementation-efforts

Overall BMD Implementation Process
8 Tasks That Can be Undertaken (Schedule Example)

Task		Sub Task	Description	Years							
				-1	1	2	3	4	5	6	7
1	**Understanding the why and benefits of Performance Specifications**			●							
2	**Overall Planning**	2.1	Identification of Champions		●						
		2.2	Establishing a Stakeholders Partnership		●						
		2.3	Doing Your Homework		●						
		2.4	Establishing Goals		●						
		2.5	Mapping the Tasks		●						
		2.6	Identifying Available External Technical Information and Support (periodically)		●	―	―	―	―	●	
		2.7	Developing an Implementation Timeline		●	―	―	―	―	●	
3	**Selecting Performance Tests**	3.1	Identifying Primary Modes of Distress.		●	―	●				
		3.2	Identifying and Assessing Performance Test Appropriateness.		●	―	●				
		3.3	Validating the Performance Tests			●	―	―	●		
4	**Performance Testing Equipment: Acquiring, Managing Resources, Training, and Evaluating**	4.1	Acquiring Equipment			●	―	―	●		
		4.2	Managing Resources				●	―	―	●	
		4.3	Conducting Initial Training			●	―	●			
		4.4	Evaluating Performance Tests				●	―	●		
		4.5	Conducting Inter-Laboratory Studies					●	―	●	
5	**Establishing Baseline Data**	5.1	Reviewing Historical Data & Information Management System			●	―	●			
		5.2	Conducting Benchmarking studies				●	―	●		
		5.3	Conducting Shadow Projects					●	―	●	
		5.4	Analyzing Production Data					●	―	●	
		5.5	Determining How to Adjust Asphalt Mixtures Containing Local Materials					●	―	―	●
6	**Specifications and Program Development**	6.1	Sampling and Testing Plans						●	―	●
		6.2	Pay Adjustment Factors (If Part of the Goals)						●	―	●
		6.3	Developing Pilot Specifications and Policies						●	―	●
		6.4	Conducting Pilot Projects						●	―	●
		6.5	Final Analysis and Specification Revisions							●	●
7	**Training, Certifications, and Accreditations**	7.1	Developing and/or Updating Training and Certification Programs						●	―	●
		7.2	Establishing or Updating Laboratory Accreditation Program Requirements					●	―	―	●
8	**Initial Implementation**										●

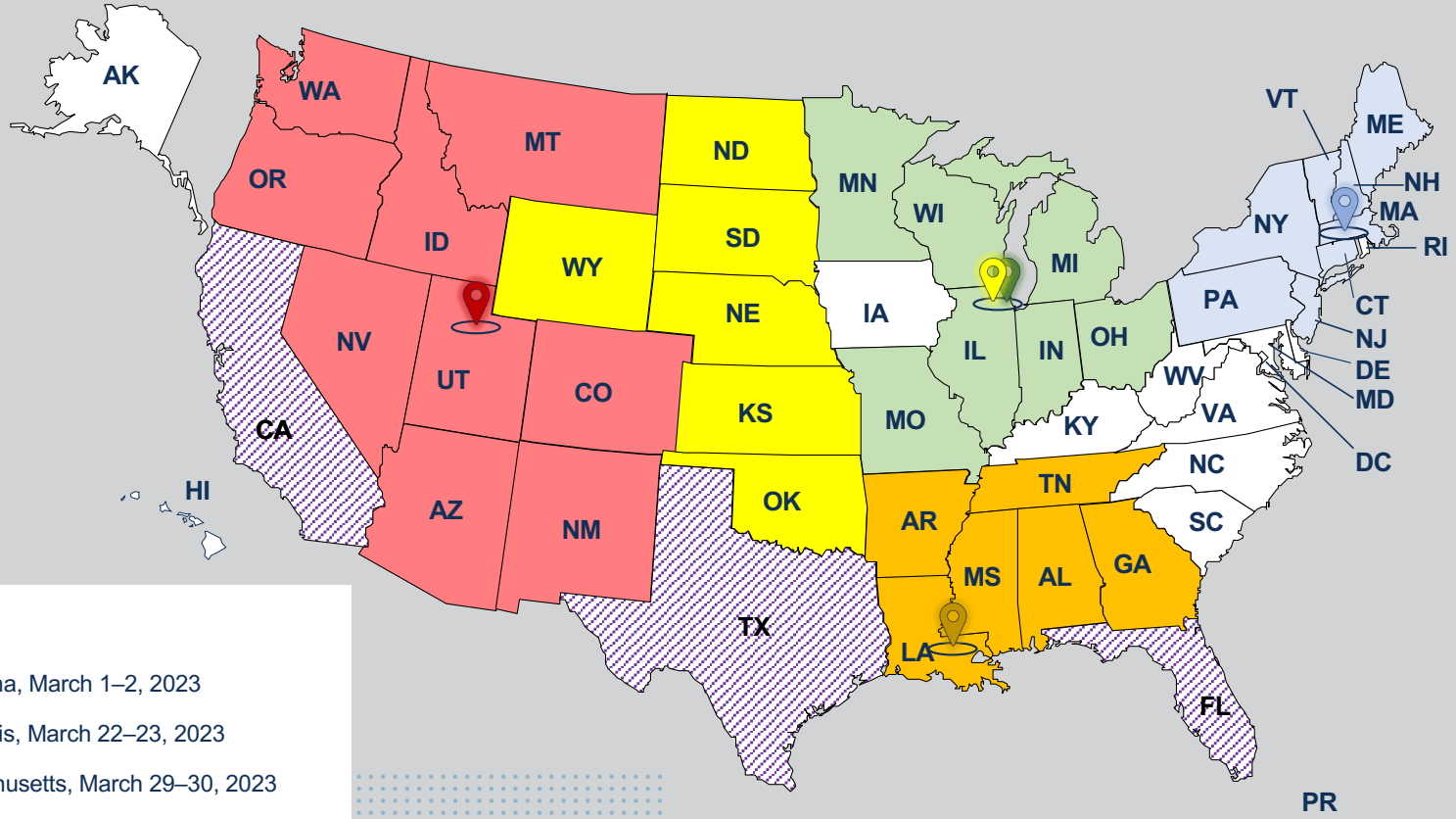
Not all tasks may be applied/considered.

Considerations to:
- Organizational structure, staffing, workspace, asphalt tonnage, etc.
- Industry experiences & practices.

Inter-related tasks or subtasks activities.

Tech Brief: Balanced Asphalt Mix Design: Eight Tasks for Implementation

Balanced Mix Design Peer Exchanges



- Meeting Location
- Southeast Peer Exchange, Louisiana, March 1–2, 2023
- North Central Peer Exchange, Illinois, March 22–23, 2023
- Northeast Peer Exchange, Massachusetts, March 29–30, 2023
- Rocky Mountain West Peer Exchange, Utah, November 28–30, 2023
- Midwest Peer Exchange, Illinois, December 13–14, 2023
- Mega-States Peer Exchange

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Critical Challenges

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Critical Challenges for BMD

Its more than just technical items!

Management Challenges

Technical Challenges

Management Challenges

- Change Management.
- Cost-Benefit Analysis
- Regulatory Compliance & Risk Management.
- Resource Allocation.
- Implementation Planning.
- Stakeholders Engagement.

- Integration with Existing Practices.
- Education, Training, & Skill Development.
- Information Sharing & Collaboration Among Peers

Technical Challenges

- BMD Tests Validation
- Testing Procedures & Protocols
- Variabilities
- Database Setup, Collection, Analysis, & Management.
- Pathway for Use in Field Quality Assurance (QA).
- Volumetrics Historical Usage

Management Challenges

Change Management

- Resistance to change.
  - Familiar with traditional mix design.
  - Shift culture.
- Change management strategies.
  - Communicate.
  - Describe why.
  - Promote buy-in (what's in it for me).
  - Plan.

Resistance to change

- Inspiring confidence.
- Having competing priorities (relative benefits).
- Facing two opposite situations for innovation?

Shift culture

- Receiving mixed reactions for test selections.
- Having a clear vision.

Communication

- Identifying champions locally (buy-in).
- Communicating the "why" when recent modifications implemented (e.g., regressed AV).
- Understanding/documenting relative benefit.
- Creating a plan with timelines.

Management Challenges
Cost-Benefit Analysis

- Benefits to stakeholders.
- Cost-effectiveness.
- Justify the investment.
  - Improved pavement performance.
  - Longevity.
  - Reduced maintenance costs.
  - Support sustainability efforts.

Benefits/cost-effectiveness

- Allowing innovation.
- Perception of increasing costs (upper management hesitations).
- Opportunities for bidding low-risk routes where BMD option would allow loosening/ removal of certain volumetric mix design & consensus quality criteria for cost analysis.

Justify the investment

- Documenting improved pavement performance.

Management Challenges

Regulatory Compliance & Risk Management

- Mix design and acceptance procedures comply with industry standards.
- Identifying and mitigating risks associated with implementation of BMD (e.g., performance issues, budget overruns).

Industry Standards & Risk Management (1 of 2)

- Hesitation from the upper management due to the current elevated prices and the perception that adding more or different criteria will increase costs.

- Agencies need to find opportunities to assume some perceived up-front risk to be able to prove out the BMD concept in real-world applications.

Management Challenges

Regulatory Compliance & Risk Management

- Mix design and acceptance procedures comply with industry standards.
- Identifying and mitigating risks associated with implementation of BMD (e.g., performance issues, budget overruns).

Industry Standards & Risk Management (2 of 2)

- Ideal if the State bid low-risk routes where the BMD option would allow the loosening/removal of certain volumetric mix design and consensus quality criteria for cost analysis.
- Documentation of improved pavement performance.

Management Challenges

Resource Allocation

- Personnel.
- Funding.
- Equipment.
- Initial investments and ongoing operational costs.

Personnel (1 of 3)

- Identifying staffing need to implement BMD, particularly when there are many competing priorities within an agency.

- Finding qualified workforce while adding new procedures to existing volumetric approval processes (e.g., Needing to hire additional inspectors at asphalt plants and to provide additional training to inspectors).

Management Challenges

Resource Allocation

- Personnel.
- Funding.
- Equipment.
- Initial investments and ongoing operational costs.

Personnel (2 of 3)

- Consideration of current staffing resources and additional workload for implementing BMD (effort to collect samples and process BMD testing).
- Significant lag time between sampling and testing of field-produced asphalt mixtures (contributing to variability in test results).

Management Challenges

Resource Allocation

- Personnel.
- Funding.
- Equipment.
- Initial investments and ongoing operational costs.

Equipment (3 of 3)

- Committing resources and equipment when rolling up from central design to statewide regional testing.

Management Challenges

Implementation Planning

- Formal roadmap.
- Defined goals and scope.
- Avoid missteps and minimize re-work.

Roadmap, goals, scope (1 of 2)

- Formalizing BMD approach including planning with tasks and timelines.
- Creating a framework or documented timeline including a plan to move from Approach A to Approach D.
- Realizing and seeing a greater focus on strategic planning and timeline.
- Take the time to develop and documents a strategic plan with short and long-term goals.

Management Challenges

Implementation Planning

- Formal roadmap.
- Defined goals and scope.
- Avoid missteps and minimize re-work.

Avoid missteps (2 of 2)

- Need not accelerate the implementation process, e.g., thoughtful planning, lessons learned.
- Recognizing that implementation of BMD will take time and might face setbacks during the process,

Management Challenges

Stakeholders Engagement

- Clear communication.
- Engage stakeholders.
- Collaboration.

Stakeholders Engagement (1 of 2)

- Identifying ways to partner with industry during implementation to ensure buy-in.
- Needing to formulate a dedicated task force to create more engagement and buy-in from the asphalt community.
- Identifying champions locally to create buy-in at higher levels.

Management Challenges

Stakeholders Engagement

- Clear communication.
- Engage stakeholders.
- Collaboration.

Stakeholders Engagement (2 of 2)

- Leverage contractors / consultants / academia when State DOT staffing resources are inadequate for testing procedures.

- Communicating and working with industry partners (producers, regional materials / construction, academia, etc.) to achieve a version of BMD implementation that is feasible.

Management Challenges

- Change Management.
- Cost-Benefit Analysis
- Regulatory Compliance & Risk Management.
- Resource Allocation.
- Implementation Planning.
- Stakeholders Engagement.

- Integration with Existing Practices.
- Education, Training, & Skill Development.
- Information Sharing & Collaboration Among Peers

Technical Challenges

- BMD Tests Validation
- Testing Procedures & Protocols
- Variabilities
- Database Setup, Collection, Analysis, & Management.
- Pathway for Use in Field Quality Assurance (QA).
- Volumetrics Historical Usage

Technical Challenges

BMD Tests Validation

- Relationship of mechanical tests to field performance.
- Mechanical tests correlate to the distress of interest.
- Specification criteria for mix design approval and possibly production acceptance.

BMD Tests Validation (1 of 3)

- Start validation efforts early with a documented plan and data collection plan.
- Gain confidence in mechanical tests and its correlation with distress of interest.
- Need for a BMD validation framework.

Technical Challenges

BMD Tests Validation

- Relationship of mechanical tests to field performance.
- Mechanical tests correlate to the distress of interest.
- Specification criteria for mix design approval and possibly production acceptance.

BMD Tests Validation (2 of 3)

- Should include asset management frameworks – linking up data is a challenge that needs to be overcome to present information to decision makers and upper management.
- Unsure how reliable the PMS data is for establishing cracking test criteria given how cracking data is reported.

Technical Challenges

BMD Tests Validation

- Relationship of mechanical tests to field performance.
- Mechanical tests correlate to the distress of interest.
- Specification criteria for mix design approval and possibly production acceptance.

BMD Tests Validation (3 of 3)

- Short evaluation period for field BMD projects (in-service less than 5 years and most of them less than 3 years).
- Accelerated loading facilities have assisted in some of this effort; however, the State does not have a representative number of asphalt mixtures evaluated in this manner or necessarily in representative climates.

Technical Challenges

Testing Procedures & Protocols

- Include lab and field produced asphalt mixtures.
- Sample handling and conditioning protocols.
- Define lag time (how long after mixing can the specimens be compacted) and dwell time (how long after compaction can the specimens still be tested and get acceptable results).

Testing Procedures & Protocols (1 of 2)

- Need to achieve sampling and testing consistency.
- Need for standard protocols for handling, storing, and aging

- Very limited information or standards are available on sample handling, reheating, and conditioning which led to the loss of significant data. This forces agencies to develop their own procedures and protocols which require time and effort.

Technical Challenges

Testing Procedures & Protocols

- Include lab and field produced asphalt mixtures.
- Sample handling and conditioning protocols.
- Define lag time (how long after mixing can the specimens be compacted) and dwell time (how long after compaction can the specimens still be tested and get acceptable results).

Testing Procedures & Protocols (2 of 2)

- Need for an aging protocol to shorten test time and establish new thresholds for use during production.
- Moisture damage testing and protocols:
  - Rutting vs. stripping?
  - Is a moisture susceptibility test needed?
  - Moisture conditioning?

Technical Challenges

Variabilities

- Variability of test results.
  - Variability erodes confidence.
- Sensitivity of test results.
  - Sensitivity is needed.

Variabilities (1 of 2)

- Need to reducing variabilities in mechanical test results.
- Concerns about the observed variability in BMD cracking tests that undermines the confidence in BMD.
- Large differences in test results when theoretical maximum specific gravity measurements differed between contractor and agency laboratories.

Technical Challenges

Variabilities

- Variability of test results.
  - Variability erodes confidence.
- Sensitivity of test results.
  - Sensitivity is needed.

Variabilities (2 of 2)

- Concerns about the variability between different devices for a given test.
- BMD tests can be sensitive to change in asphalt binder source.
- Concerns about the variability during production at the asphalt mixture plant.
- Laboratory test results from mix design can differ substantially from the test results on plant-produced material.

Technical Challenges

Database Setup, Collection, Analysis, & Management

- Database setup.
  - Track testing parameters.
  - Track field performance.
- Data management can persuade decision makers.

Database Setup, Collection, Analysis, & Management (1 of 2)

- Need for a data wish list to be collected as part of validation projects.
- Organizing materials database has been a struggle. Additional guidelines, including templates and formatting needs are useful for initial database setup.
- Need help in linking asphalt mix design data with construction QA data and field performance data.

Technical Challenges

Database Setup, Collection, Analysis, & Management

- Database setup.
  - Track testing parameters.
  - Track field performance.
- Data management can persuade decision makers.

Database Setup, Collection, Analysis, & Management (2 of 2)

- Incorporate as many data fields and raw data as possible when initializing BMD databases.
- Use BMD database to tie BMD tests to construction and asset management data (e.g., mix design info, mixture type, raw material sources, project location, pre-existing pavement condition, lot and sub-lot numbers, BMD test results, field performance, etc.).

Technical Challenges

Pathway for Use in Field QA

- Desire to use BMD principles in mix design.
- BMD for acceptance:
  - Test strips?
  - Go-no-go?
  - Testing frequency?
  - Quality measures?
  - Payment?
  - Thresholds?

Pathway for Use in Field QA (1 of 3)

- Need for an aging protocol to shorten test time and establish new thresholds so test is applicable during production.
- Need for a greater frequency of sampling for BMD mechanical tests. Testing frequency and lot size has been a major challenge.
- Finding surrogate BMD tests that will provide quicker turnaround of test results for QA.

Technical Challenges

Pathway for Use in Field QA

- Desire to use BMD principles in mix design.
- BMD for acceptance:
  - Test strips?
  - Go-no-go?
  - Testing frequency?
  - Quality measures?
  - Payment?
  - Thresholds?

Pathway for Use in Field QA (2 of 3)

- Assigning BMD test results weight factors for pay factors.
  - What BMD tests and weight factors should be used along other volumetric properties?
  - Should same weight factor be used for cracking and rutting tests?
- In-place density is still thought to be critical to include in acceptance.

Technical Challenges

Pathway for Use in Field QA

- Desire to use BMD principles in mix design.
- BMD for acceptance:
  - Test strips?
  - Go-no-go?
  - Testing frequency?
  - Quality measures?
  - Payment?
  - Thresholds?

Pathway for Use in Field QA (3 of 3)

- Fear that the focus is too much on BMD tests for pay and lose sight of production control in terms of consistent production, raw materials, and plant operations.
- (Consistency = Quality)

Technical Challenges

Volumetrics Historical Usage

- Volumetric properties alone have shortcomings.
- Relaxing volumetric requirements?
  - First, confirm BMD test results to pavement performance (validation).
- Innovation.
  - Ability to have greater access to more resources and responsible use of materials.

Volumetrics Historical Usage (1 of 3)

- Having and inspiring confidence in moving away from volumetric properties to BMD tests is critical for BMD implementation.

- Are mechanical tests run through BMD enough to control consistency without volumetric properties? What other parameters can be used to control consistency?

Technical Challenges

Volumetrics Historical Usage

- Volumetric properties alone have shortcomings.
- Relaxing volumetric requirements?
  - First, confirm BMD test results to pavement performance (validation).
- Innovation.
  - Ability to have greater access to more resources and responsible use of materials.

Volumetrics Historical Usage (2 of 3)

- Are the BMD tests sensitive enough to asphalt mixture composition and components (e.g., sensitivity to polymer modification, recycled materials, binder source)?
- Will industry and leadership feel enough confidence using tests in lieu of volumetric properties given current testing technology and practices?

Technical Challenges

Volumetrics Historical Usage

- Volumetric properties alone have shortcomings.
- Relaxing volumetric requirements?
  - First, confirm BMD test results to pavement performance (validation).
- Innovation.
  - Ability to have greater access to more resources and responsible use of materials.

Volumetrics Historical Usage (3 of 3)

- Can the role of volumetric properties in the mix design and acceptance stage be different?
  - Which volumetric properties to use?
  - Which criteria to relax? and by how much?
- Focus on shadow and pilot projects.

Management Challenges

- Change Management.
- Cost-Benefit Analysis
- Regulatory Compliance & Risk Management.
- Resource Allocation.
- Implementation Planning.
- Stakeholders Engagement.

- Integration with Existing Practices.
- Education, Training, & Skill Development.
- Information Sharing & Collaboration Among Peers

Technical Challenges

- BMD Tests Validation
- Testing Procedures & Protocols
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- Database Setup, Collection, Analysis, & Management.
- Pathway for Use in Field Quality Assurance (QA).
- Volumetrics Historical Usage

Common Challenges

Integration with Existing Practices

- Address technical and management perspectives.
- Compatibility with existing specifications and standards must be ensured.

Integration with Existing Practices (1 of 2)

- Need to bridge the gap between research and practice.
- Identify internal gaps towards implementing BMD including training.
- The required frequency of testing under BMD can prove challenging at the beginning of the implementation cycle.
- Identified frequency of testing as the biggest hurdle in implementing BMD.

Common Challenges

Integration with Existing Practices

- Address technical and management perspectives.
- Compatibility with existing specifications and standards must be ensured.

Integration with Existing Practices (2 of 2)

- Test the impact of new additives/materials on the mixture's mechanical properties.
- 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.

Common Challenges

Education, Training, & Skill Development

- BMD approaches.
- Implementation methods.
- New qualifications may be needed.
- Testing procedures, data analysis, and interpretation.

Education, Training, & Skill Development (1 of 2)

- A challenge being faced is the high staff turnover rate from both agency and contractor side necessitating a continuous education of new staff.

- Need for informing and educating area personnel as the BMD concept may be new to project engineers and lab personnel.

Common Challenges

Education, Training, & Skill Development

- BMD approaches.
- Implementation methods.
- New qualifications may be needed.
- Testing procedures, data analysis, and interpretation.

Education, Training, & Skill Development (2 of 2)

- Consider formal training workshops on new procedures.
- Need more documentation with the implementation of BMD, including of existing and intended future practices.

Common Challenges

Information Sharing & Collaboration Among Peers

- Initiate regional collaboration to support implementation of BMD.
- Share technical and management information.

Information Sharing & Collaboration Among Peers (1 of 2)

- States can work together to decide on handling, conditioning and long-term aging procedures given their geographical proximity and resemblances for climate and materials.

- Help in accelerating the implementation of BMD by providing consistency among the States, whenever possible.

Common Challenges

Information Sharing & Collaboration Among Peers

- Initiate regional collaboration to support implementation of BMD.
- Share technical and management information.

Information Sharing & Collaboration Among Peers (2 of 2)

- Need for coordinating such opportunities, identifying topics for discussion, and exploring available funds

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Wrap-Up

BMD Case Studies ~~Virtual~~ Workshop

- https://www.fhwa.dot.gov/pavement/asphalt/
- https://www.fhwa.dot.gov/pavement/asphalt/pubs/20210722_bmd_workshop_flyer_508c_finalv3.pdf
- Contact Derek Nener-Plante derek.nenerplante@dot.gov

Now offered In-Person!


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Balanced Mix Design (BMD) Case Studies Virtual Workshop: Moving Forward with Implementation

Location

The **free virtual workshop** will be delivered using Microsoft Teams or any other virtual meeting platform accepted by a State Department of Transportation (DOT).

Length

The workshop is a total of six hours and will include multiple segments with a maximum of three hours per segment. The workshop can be delivered over the course of several days.

Target Audience

The successful implementation of BMD will need to be a team effort. Thus, the target audiences for the workshop are managers and practitioners interested in the implementation of BMD from State DOTs, industry, academia, and consultants. This involves participants from various offices of a State DOT, such as materials, pavement design, construction, and pavement management.

Description

This free Federal Highway Administration (FHWA) workshop will provide State DOTs with knowledge on how to get started and/or move forward with the implementation of BMD as learned from in-depth case studies of key State DOTs. It is **customized** to a State DOTs current situation with its BMD implementation program.

This unique workshop includes providing managers and practitioners with knowledge on:

a. the overall BMD process and its benefits;
b. the planning and activities needed for the selection, evaluation, and implementation of performance tests for routine uses in a BMD process; and
c. positive practices and lessons learned by key State DOTs.

The workshop will focus on a BMD implementation process that was developed and conducted from in-depth case studies of key State DOTs.

Outcomes

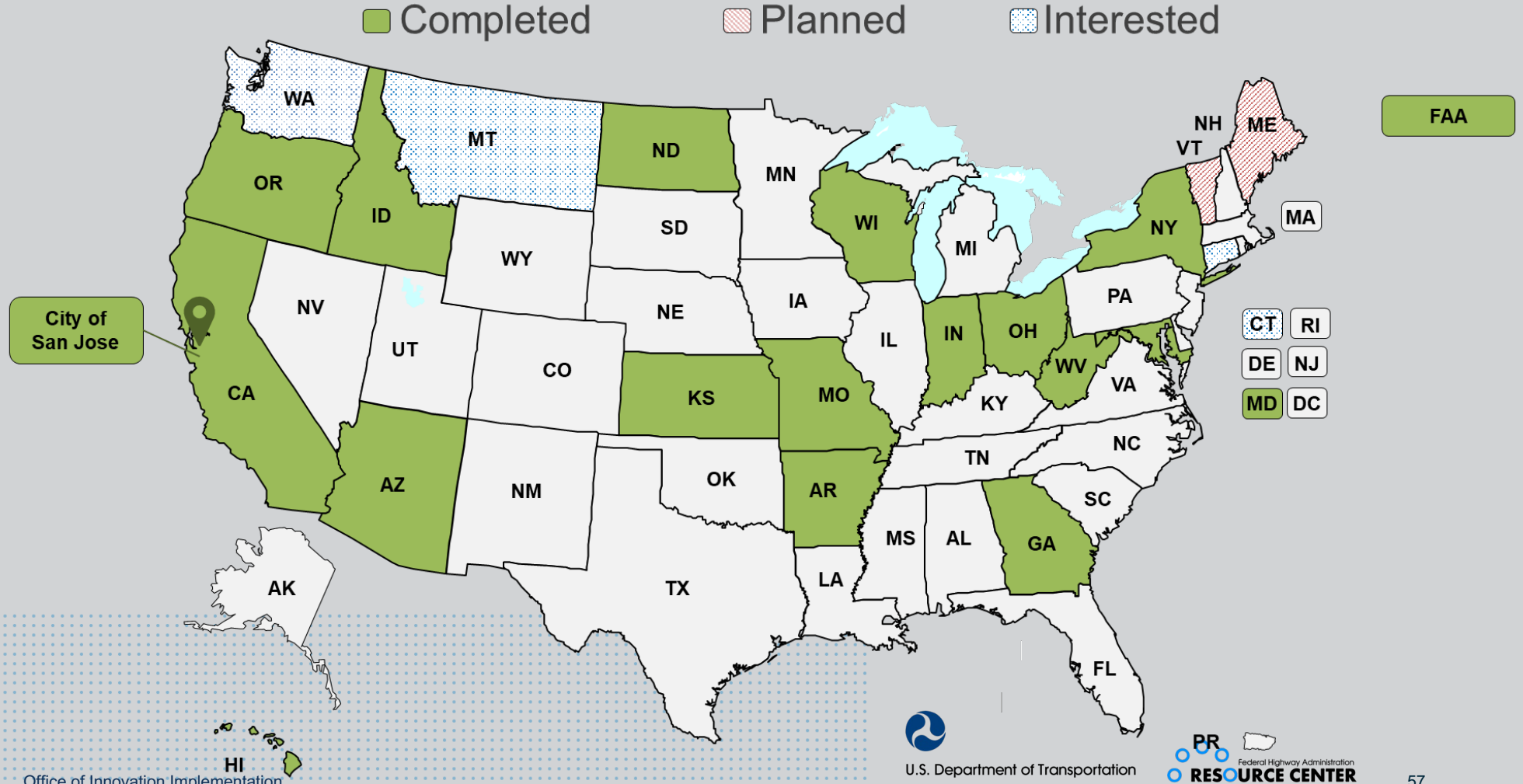
Upon completion of the workshop, participants will be able to:

- Understand the overall benefits of BMD.
- Recognize the planning and coordination effort associate with the implementation process of BMD.
- Identify the tasks that need to be completed for the development and implementation of BMD.
- Recognize successful key State DOTs practices and experiences related to BMD.
- Recognize available external technical information and support.

Register Today

Contact **Derek-Nener-Plante** at derek.nenerplante@dot.gov for more information.

FHWA Balanced Mix Design Case Studies Virtual/In-Person Workshop



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Questions?

Thank you for your attention!

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