Different Approaches to BMD Implementation

Its not a one-size fits all approach

SEAUPG
November 15th, 2022

Derek Nener-Plante, M.S., P.E.
Pavement & Materials Engineer
Resource Center
Office of Innovation Implementation

Disclaimers

- The contents of this presentation do not have the force and effect of law and are not meant to bind the public in any way. This presentation is intended only to provide information to the public regarding existing requirements under the law or agency policies.
- The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this presentation only because they are considered essential to the objective of the presentation. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.
- All AASHTO & ASTM standards mentioned in this presentation content are private, voluntary standards and compliance with them are not required under Federal law.
- Unless noted otherwise, FHWA is the source for all images in this presentation.

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, Task C.1.7
  - The content in this presentation is derived in part from work under cooperative agreement cooperative agreement No. 693JJ31850010. The U.S. Government assumes no liability for the use of the information.

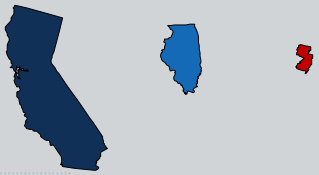
Abbreviations and Acronyms

- AASHTO – American Association of State Highway and Transportation Officials
- ABR: AC: Asphalt content
- ALF: Accelerated loading facility
- AQC: Acceptance quality characteristic
- ASTM: American Society for Testing and Materials
- BMD: Balanced Mixture 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: 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
- SGS: 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

Why do you care?

What are you going to get out of this?

Provide examples of different approaches to BMD implementation based upon different factors for agencies.



Preview of Takeaways

Demonstrate how BMD approaches will be very different for different agencies; representative of their goals, capabilities, and program attributes.

Outline

- Background
- Differences in:
  - Benefits
  - Goals
  - Distresses for Tests
  - Validation of BMD
  - Quality Assurance programs
  - Training & Certifications
- Implementation Examples

U.S. Department of Transportation
Federal Highway Administration

RESOURCE CENTER

Background

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.*"

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

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.

Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 8

Definitions (Cont'd)

Reality of BMD Approach

This change may be due to asphalt content, or gradation (more effect asphalt), PG binder change

BMD is not solely about achieving the 'right' quantity of asphalt!

Property #1 ...king Resistance

Acceptable

Acceptable

Property #2
Rutting Resistance

BMD Conc...

...ire a fully ...lanced' mixture – must meet certain criteria for performance. Other strategies available to achieve performance.

Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER

Performance Tests for BMD

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

Source: NCAT Source: NCAT

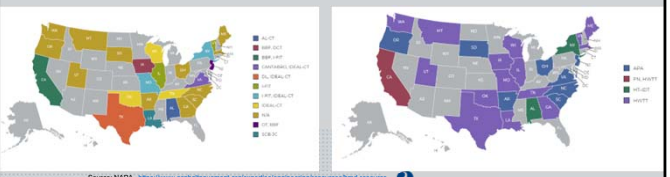
Source: James Musselman Source: NCAT

Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 10

Common Performance Tests in U.S.

- Many State DOT's moving to BMD considering use of IDEAL-CT and HWTT
  - Balance desire for validity, performance prediction, and practicality



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

Office of Innovation Implementation

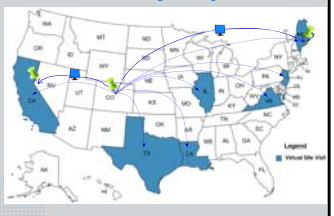
U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 11

Background

Case Studies of Key State DOTs (Virtual Site Visits)

- Pre-visit kickoff & planning web conferences.
- Review of agency documents (policy, specifications, reports, etc.).
- 2–4 day virtual site visit.
  - Obtain detailed understanding of agency practices & lessons learned.
- Products
  - Individual State DOT site visit reports.
  - Overall summary report
  - Tech Brief

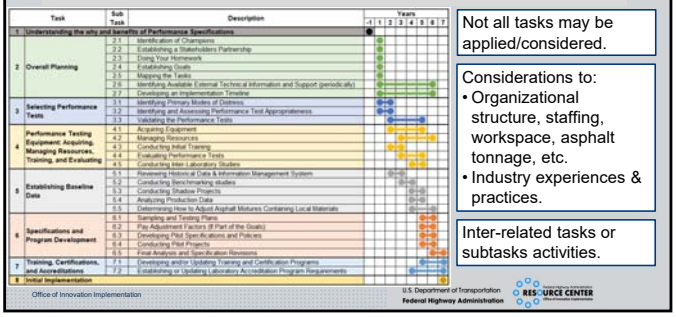
- https://www.unr.edu/wrsc/tools/asphalt/dapt-publications
- https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide/training-resources



Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 12

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



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.

Office of Innovation Implementation
U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER

So similar yet so different....

BMD Similarities
- Collaboration with Stakeholders
- Doing your homework
- Inter-laboratory studies
- Benchmarking

BMD Differences
- Benefits
- Goals
- Distresses for Tests
- Validation of BMD
- Quality Assurance programs
- Training & Certifications

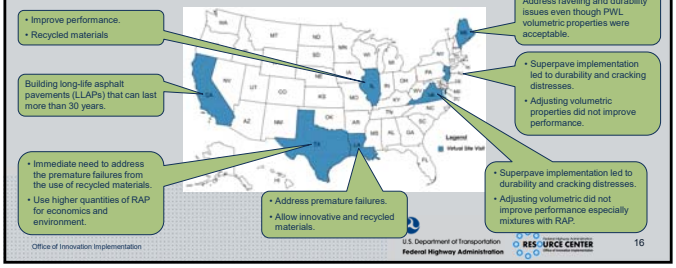
Office of Innovation Implementation
U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER
14

U.S. Department of Transportation
Federal Highway Administration
RESOURCE CENTER

Different "Why's"

The "Why" & Benefits of BMD

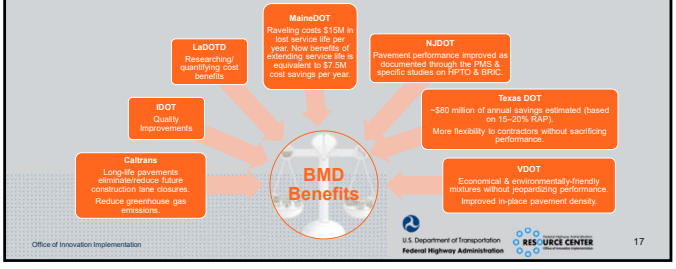
State DOT Examples of the "Why" / Motivation



Office of Innovation Implementation
U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER
16

The "Why" & Benefits of BMD

State DOT Examples of the Benefits



Office of Innovation Implementation
U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER
17

U.S. Department of Transportation
Federal Highway Administration
RESOURCE CENTER

Different Goals

Establishing Goals

- BMD program goals are State-specific.
- Goals help guide decision making.
- Overall BMD program scope need to be defined.

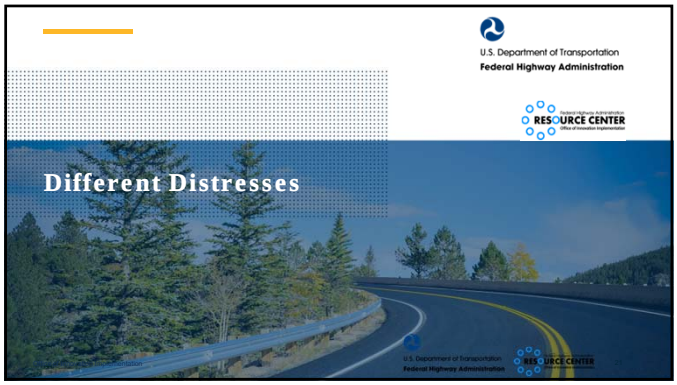
Establishing BMD Goals is important for any agency moving to implement!

Goals defined with considerations to:
- State DOT's organizational structure, staffing level, workspace, annual asphalt tonnage, etc.
- Industry experiences and practices.

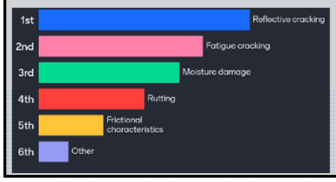
Scope for the application of the BMD program onto projects:
- Varies by State DOTs.
- Most significant factors observed: mixture quantity & roadway/corridor classification.

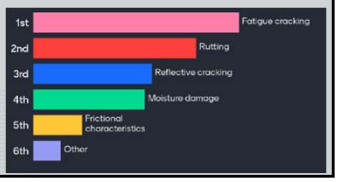
Establishing Goals

State DOT	Project Scope	Goal: Design	Goal: Acceptance
Caltrans	High-traffic projects with ≥100,000 tons of asphalt mixture produced.	X	X
IDOT, LaDOTD	All projects (phased approach).	X	X
MaineDOT	All interstate & high investment projects.	X	
NJDOT	Evolving from: specialty mixture design/ specialty acceptance/ BMD for dense-graded mixtures.	X	(X)
TxDOT	All mixtures / phased implementation.	X	X



Ranking of Importance of Distresses





Validating the Performance Tests

IDOT Example for I-FIT (4 Approaches)

CONSTRUCTION AND PERFORMANCE MONITORING OF VARIOUS ASPHALT MIXES IN ILLINOIS: 2016 INTERIM REPORT

ALF Experiment at TFHRC
- Initial criteria based on test results of ALF mixtures.
- Criteria was based on fatigue cracking

Experimental Projects (5)
- Research study to construct & monitor performance of asphalt overlays.
- Focused on reflective cracking

Pilot Projects
- Annual coring & distress surveys.
- Comparison of FI to observed distresses.

Ongoing Monitoring of Projects
- Continue to validate criteria: sampling & testing; monitoring field performance; & comparing the results.

Validating the Performance Tests

NJDOT Example for OT (3 Approaches)

SPS-5 Sections
- Testing of asphalt mixtures.
- Comparison of test results with the field performance.

Pavement Management System (PMS)
- Building a database of test results.
- Comparison of field performance to lab test results.
- Identify cracking type and mechanism.
- Performance of conventional and proprietary mixtures.

Robust Validation of Test Criteria

Ongoing Monitoring of Projects
- Specific select projects.
- Continuous communication and partnership between material, pavement design, and pavement management groups.

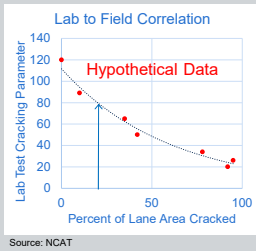
Validating the Performance Tests

Wisconsin DOT

- WisDOT assessing long-term field performance of BMD pavements validate criteria through construction of experimental test sections.
- Range of HWTT CRD and CT_{Index} is more important than specific materials.
- 500 ft test sections ≈ 75 tons per surface layer.

HWTT Corrected Rut Depth	IDEAL CT Index (after 6-hours @ 135°C aging)	
	> 65	< 35
> 7.0 mm	①	③
< 3.5 mm	②	④
V-grade binder	⑤	⑥

Source: NCAT



Source: NCAT

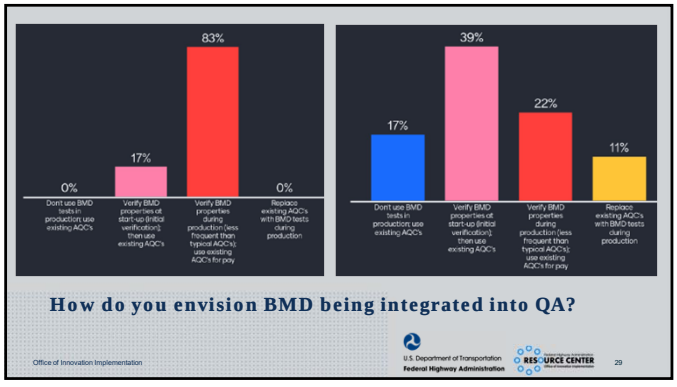
Program Development & Initial Implementation

Specifications and Program Development (Cont'd)

- Based on State DOT goals (Sub-Task 2.4):
  - Acceptance & quality control options.

State DOT	Acceptance
Caltrans, LaDOTD, VDOT	Volumetric properties with performance tests for information.
NJDOT, TxDOT	Surrogate performance tests correlated to mix design approval tests.
IDOT, NJDOT, MaineDOT	Actual performance tests (same used during mix design).
NJDOT	Performance tests with pay adjustment factors.

BMD tests alone likely not enough to ensure consistency and quality.



Training & Certifications

Caltrans
- Performance tests in both lab accreditation & tester certification (AASHTO T 321, 324, 378, etc.)
- Just-in-time training from UCPRC.
  - Before the start of project.
  - On performance testing & sample preparation.
  - Included industry & Caltrans.
  - UCPRC staff visited contractors' labs for training.

TxDOT
- Hot Mix Asphalt Center (HMAC) certification program –TXAPA.
  - Tex-242-F Hamburg Wheel-Tracking Test.
  - Training videos provided (https://vimeopro.com/user33086364/test-procedure-videos).
- Labs must also participate in the Annual State-wide HWTT proficiency program.

Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 31

U.S. Department of Transportation Federal Highway Administration

RESOURCE CENTER

Different Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER

►Task 8

Program Development & Initial Implementation

Initial Implementation: IDOT Example

- 2019: Implemented I-FIT on all interstate projects with additional projects approved by Central Office for a total of 27 projects statewide.
- 2020: Original plan was a full Implementation of I-FIT.
  - Postponed by IDOT in order for contractors to gain more experience & become reasonably comfortable with performance test (based on contractors' feedback).

Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 33

►Task 8

Program Development & Initial Implementation

Initial Implementation: IDOT Example (Cont'd)

- 2021: Planning for the implementation of I-FIT thresholds in design & production for short-term aged specimens (including higher thresholds for SMA & IL-4.75 mixtures).
- 2022~~3~~: Allow terminally blended binder modifiers in non-polymer modified binders in conjunction with new binder performance testing protocol.

2021
implemented I-FIT thresholds in design and production for short-term aged specimens (including higher thresholds for SMA and IL-4.75 mixtures).

2022
fully implemented I-FIT thresholds in design and production for short-term and long-term aged specimens.

Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 34

►Task 8

Program Development & Initial Implementation

Initial Implementation: IDOT Example (Cont'd)

- Many contractors chose to invest in equipment, especially those operating in remote areas.
  - Some contractors partnered in equipment purchasing & ownership.
- Lab workspace can be challenging.
  - Contractor converted a storage room into a temp-controlled room to house performance testing equipment.
  - In one instance, contractor had to acquire interchangeable table jigs due to space limitation.
- Contractors have challenges in acquiring qualified technicians.
  - Having to run performance tests added to that challenge.
  - Additional training on equipment and test result calculations needed.
- No issues or challenges in meeting in-place density requirements.
- Key for success: partnership & continuous discussion between IDOT, industry, IAPA, & universities.

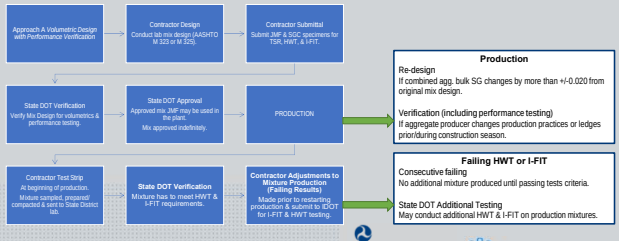
Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 35

►Task 8

Program Development & Initial Implementation

Initial Implementation: IDOT Example (Cont'd)—Mix Design (Design & Acceptance)



Office of Innovation Implementation

U.S. Department of Transportation Federal Highway Administration RESOURCE CENTER 36

►Task 8

Program Development & Initial Implementation

Initial Implementation: IDOT Example (Cont'd)

- Specs for performance testing:

T 393-21

Mixture Type		HWTT (Illinois Modified AASHTO T 324), ≤ 12.5 mm Rut Depth at a Minimum Number of Wheel Passes				FI (Illinois Modified AASHTO T 124)		TS (Illinois Modified AASHTO T 283), psi Conditioned TS		Uncon. (Illinois) TS	TSR
		PG 58-xx (or lower)	PG 64-xx	PG 70-xx	PG 76-xx (or higher)	Short-Term Aging	Long-Term Aging[a]	Non-Polymer PG	Polymer modified PG[b]		
High ESAL	IL-19.0	≥ 5,000	≥ 7,500	≥ 15,000	≥ 20,000	5.0	4.0*	≥ 80	≥ 80	≥ 70	≥ 0.85
	IL-9.5					5.0	4.0*				
	IL-4.75			≥ 10,000	≥ 15,000	12.0	–				
Low ESAL	IL-19.0L	–	–	–	–	5.0	4.0*				
	IL-9.5L	–	–	–	–	5.0	4.0*				
SMA	≤ 10 MESAL‡	≥ 5,000	≥ 7,500	≥ 15,000	≥ 20,000	10.0	10.0				
	> 10 MESAL‡					10.0	10.0				

–indicates not applicable.
‡beginning in 2021.
*required for surface courses only beginning in 2022.
*production mixture requirement. Mixture design long term aging FI is minimum of 5.0.
[a]except polymer modified PG XX-28 or lower binders shall have a minimum TS of 70 psi.

Removed in 2022 Spec Book

VFA limits Removed in 2022 Spec Book

►Task 8

Program Development & Initial Implementation

Initial Implementation: NJDOT Example

- Specialty asphalt mixtures: ~10% of total asphalt tonnage.
  - 5.1% in 2015 → 16.8% in 2018.
  - 8.3% in 2019. Drop in the percent use mainly attributable to:
    - Project prioritization & selection process.
      - Resurfacing projects not continuously ranking high in the process.
    - Delays in the procurement process.
      - Complexity of requirements stipulated in the procurement rules pushed back some of the projects until next year.
- Selection of a specialty mixture based experience.
  - Considering a project selection document to guide to junior staff.

►Task 8

Program Development & Initial Implementation

Initial Implementation: NJDOT Example (Cont'd)

- Ultimately, implement BMD for dense-graded mixtures.
- Plan:
  - Preliminary steps identified.
  - Timeframes assigned.
  - Draft 5-year plan being evaluated.

►Task 8

Program Development & Initial Implementation

Initial Implementation: NJDOT Example (Cont'd)

- Specs for performance testing:

Mixture Type	PG (AASHTO R 29)	Spec. Air Voids	TSR (AASHTO T 283)	APA @ 8,000 Loading Cycles, 64°C (AASHTO T 340)*	OT (NJDOT B-10)	FBF Life @ 15°C (AASHTO T 321)
BDWSC	–	≤3%	≥90%	≤3 mm	–	>100,000 cycles @ 1,500 micro-strain
HPTO	–	5.0±0.5%	≥85%	≤4 mm	≥600 cycles	–
BRBC	–	3.5±0.5%	≥85%	≤6 mm	≥700 cycles	–
BRBC	–	5.5±0.5%	≥85%	≤5 mm	–	>100,000,000 cycles @ 100 micro-strain
HMAP						
Surface Course	64-22*	6.5±0.5%	≥80%	≤7 mm	≥200 cycles	–
	64E-22*	6.5±0.5%	≥80%	≤4 mm	≥275 cycles	–
Intermediate and Base Course	64-22*	6.5±0.5%	≥80%	≤7 mm	≥100 cycles	–
	64E-22*	6.5±0.5%	≥80%	≤4 mm	≥150 cycles	–

Not applicable; *100 psi hose pressure and 100 lb per wheel load; †PG of asphalt binder is not specified and is determined by the mix design and mix performance testing however a certificate of analysis showing the PG continuous grading for the asphalt binder used in the mix design has to be submitted to ensure asphalt binder consistency throughout the production process.

U.S. Department of Transportation
Federal Highway Administration

RESOURCE CENTER

Wrap-Up

Takeaways to Consider:

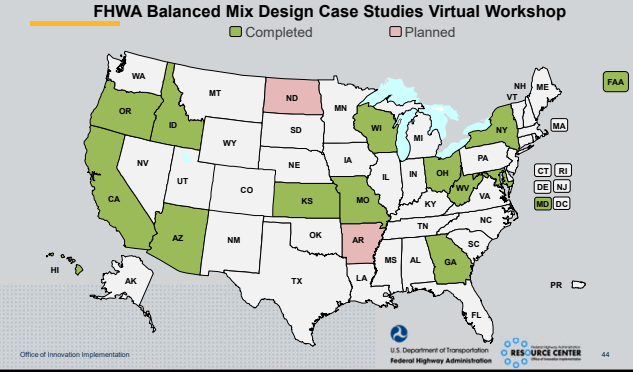
- Often reading a specification is not enough.
- BMD is far more than the tests or criteria the states uses.
- Establishing and maintaining goals for BMD is important (*Even if they change over time*).
- Differences in BMD from agency to agency are often for good reason:
  - A context specific mix design approach should be context specific to the state as well.

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

Office of Innovation Implementation
U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER
43

FHWA Balanced Mix Design Case Studies Virtual Workshop



Office of Innovation Implementation
U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER
44

Upcoming BMD Opportunity

Southeast States BMD Peer Exchange

- Organized by FHWA-UNR through DDIAPT Cooperation Agreement
- February 28-March 2 at LTRC, Baton Rogue, LA
- Agency peer exchange on progress to BMD and potential avenues of regional cooperation

Reach out to me this week if your state is interested in learning more!

Derek Nener-Plante, M.S., P.E.
Pavement & Materials Engineer
FHWA – Resource Center
derek.nenerplante@dot.gov
202-763-4017

U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER
45

U.S. Department of Transportation Federal Highway Administration
RESOURCE CENTER

Questions?

Thank you for your attention!

Derek Nener-Plante
Pavement and Materials Engineer
derek.nenerplante@dot.gov

46