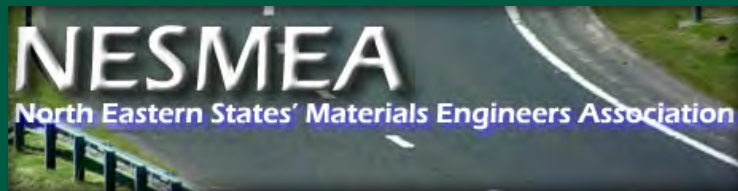


Balanced Asphalt Mixture Design – A Formula for Success



October 18, 2017
Hartford, Connecticut

Shane Buchanan

Discussion Items

1. What is Balanced Mix Design (BMD)?
2. Why the need for BMD?
3. What are the most common performance tests (rutting and cracking) for BMD?
4. What is the current national state of practice for BMD?
5. How does a BMD compare with a volumetric mix design?
6. What about acceptance testing with a BMD approach?
7. What is the future of BMD?



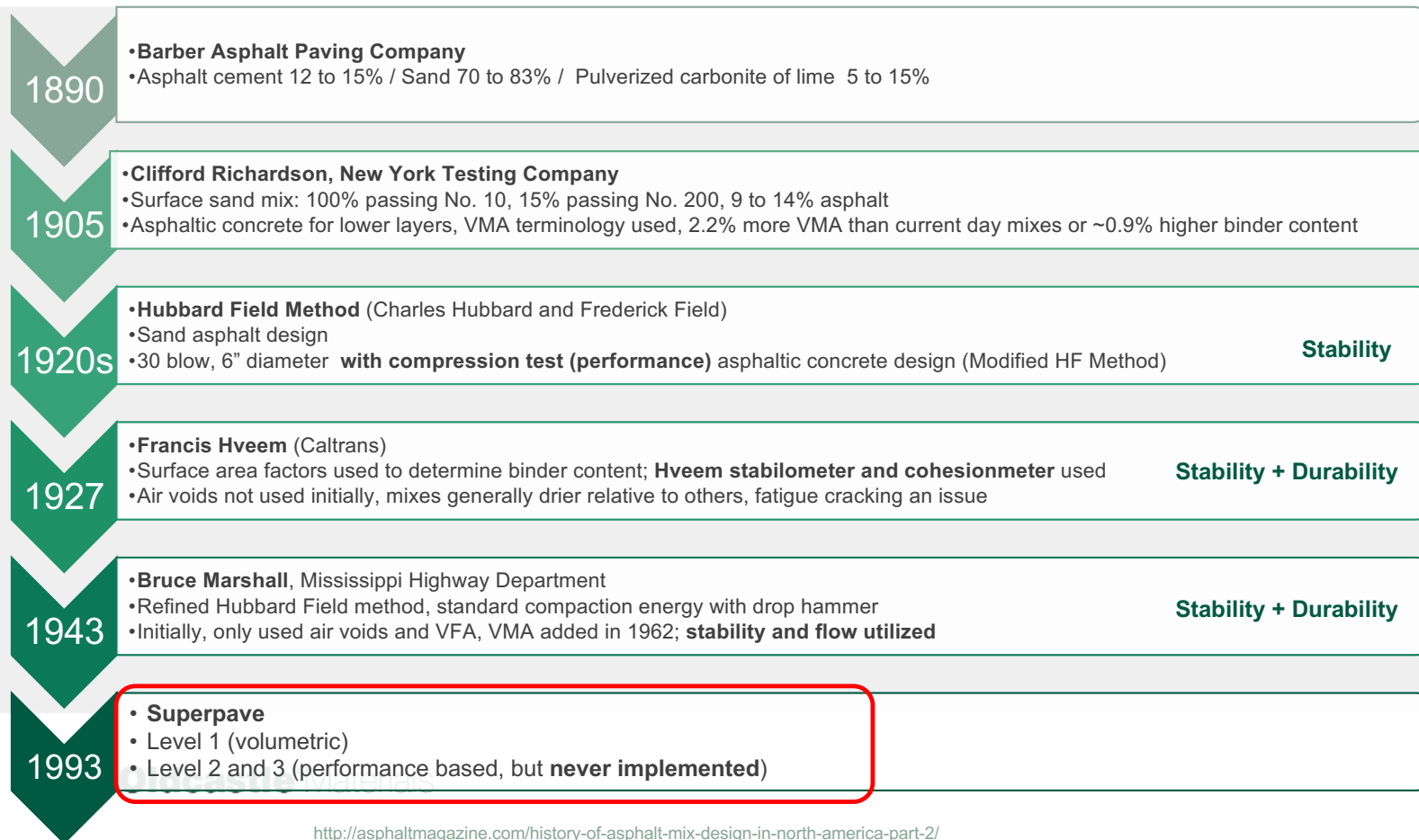
What is Balanced Mix Design (BMD)?

Balanced Mix Design Definition

- *“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.”*
- Use the right mix for the job!



History of Mix Design



<http://asphaltmagazine.com/history-of-asphalt-mix-design-in-north-america-part-2/>

Why the need for BMD?

Why the Need for a New Mix Design Approach?

- **Problems:**

- Dry mixes exist in some areas.
- Volumetrics alone can not adequately evaluate mix variables, such as recycle, warm-mix additives, polymers, rejuvenators, and fibers.

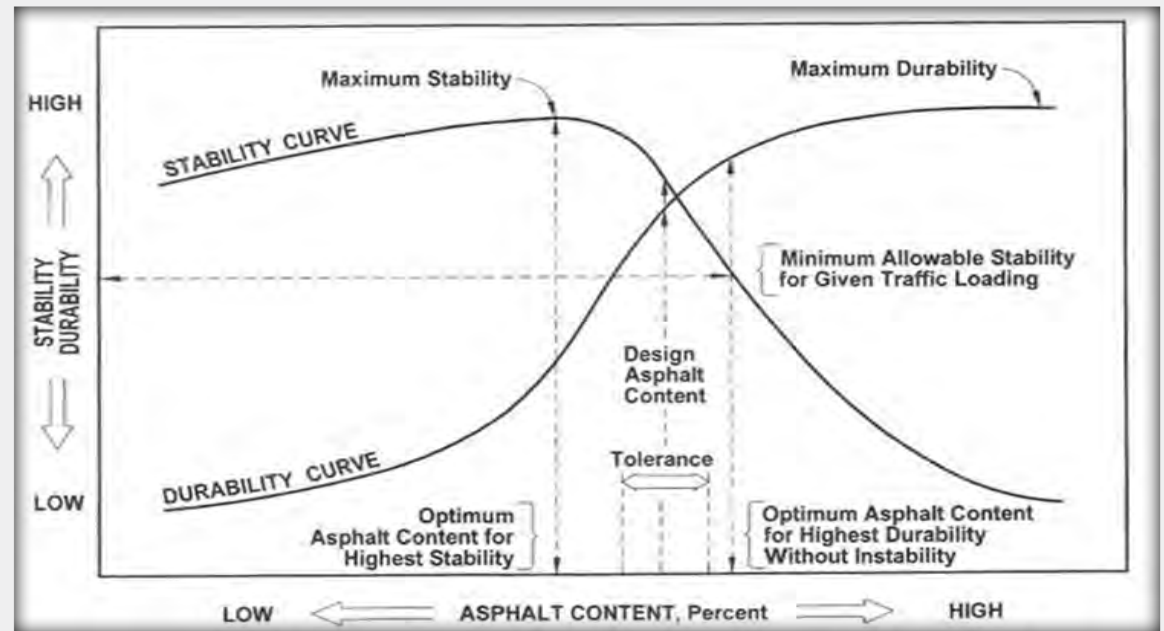
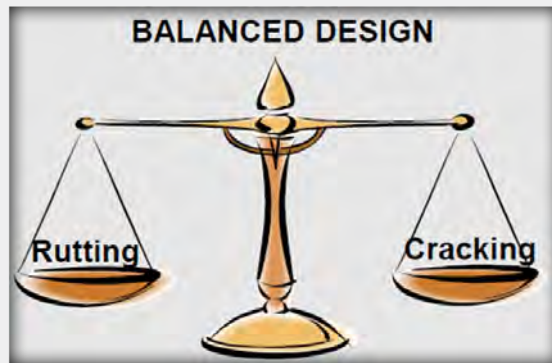
- **Solutions:**

1. **Recognize performance issues** related to dry mixes in some areas.
(Note: Many performance issues are caused by factors outside the mix design.)
2. **Increase understanding** of the factors which drive mix performance
3. **Design for performance** and not just to “the spec”.
4. **Start thinking** outside of long held “rules and constraints”
5. **Innovate!**



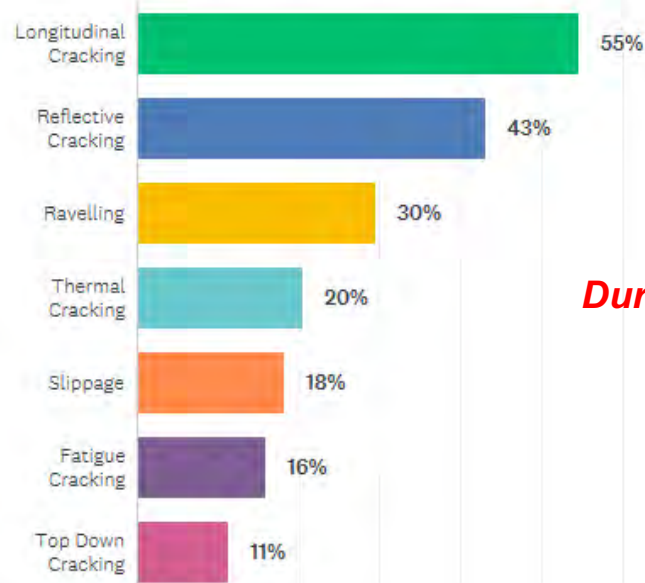
Pavement Performance General Overview

- Achieving Balanced Mixture Performance is Key to a Long Lasting Pavement



What Type Distress Is Occurring?

Within the past 5 years, what type of mix performance related distress has been most evident in your mixes?



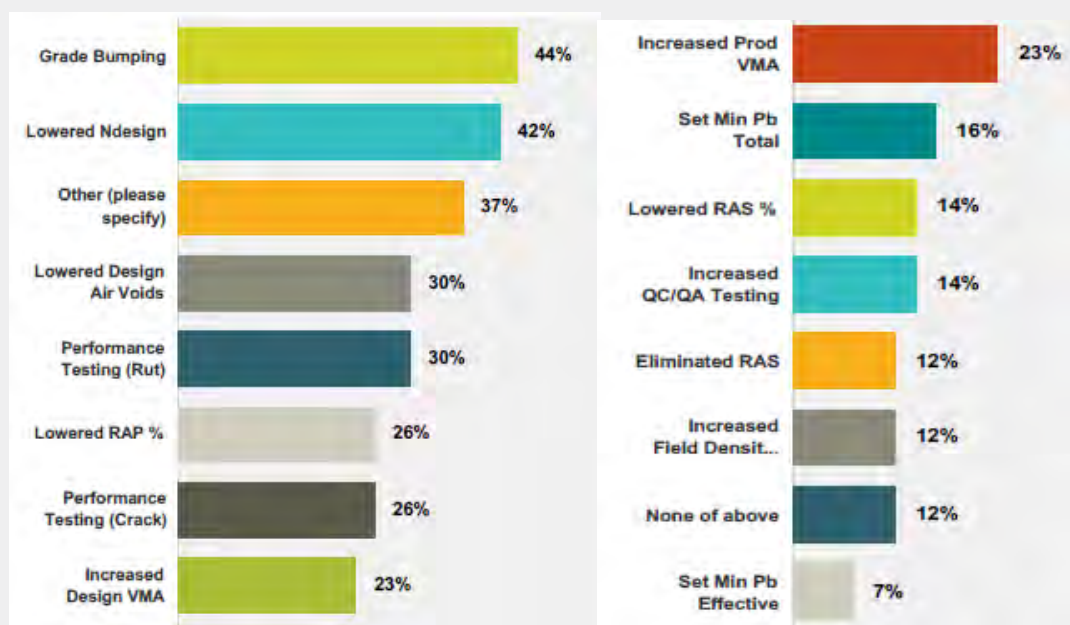
***Durability / Cracking
Dominates***



Agencies Are Searching for Solutions: Spec Changes

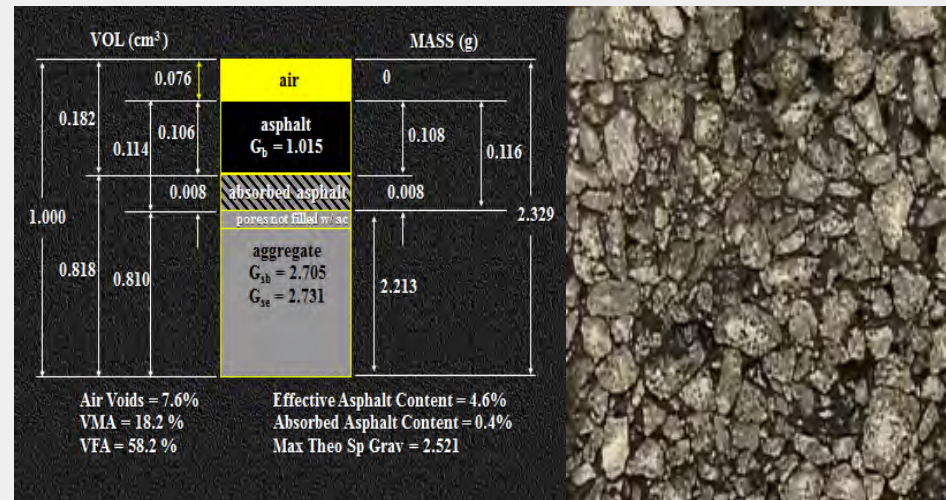
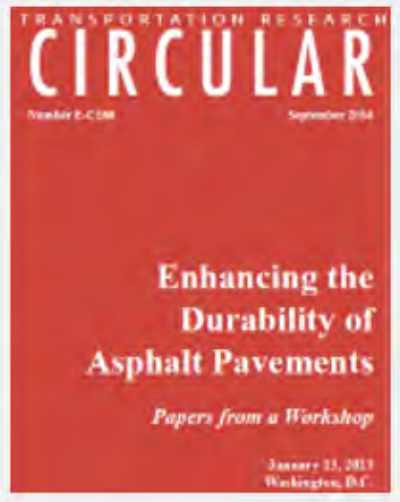
- Superpave system is becoming unrecognizable with specifications changing rapidly as agencies search for ways to improve durability
- Specifications have become convoluted and confounded
- Existing specified items compete against each other
- New requirements get added and nothing gets removed
- **Establishing true “cause and effect” is impossible**

Survey Question: Which of the following specification changes has your DOT implemented in the last 5 years?

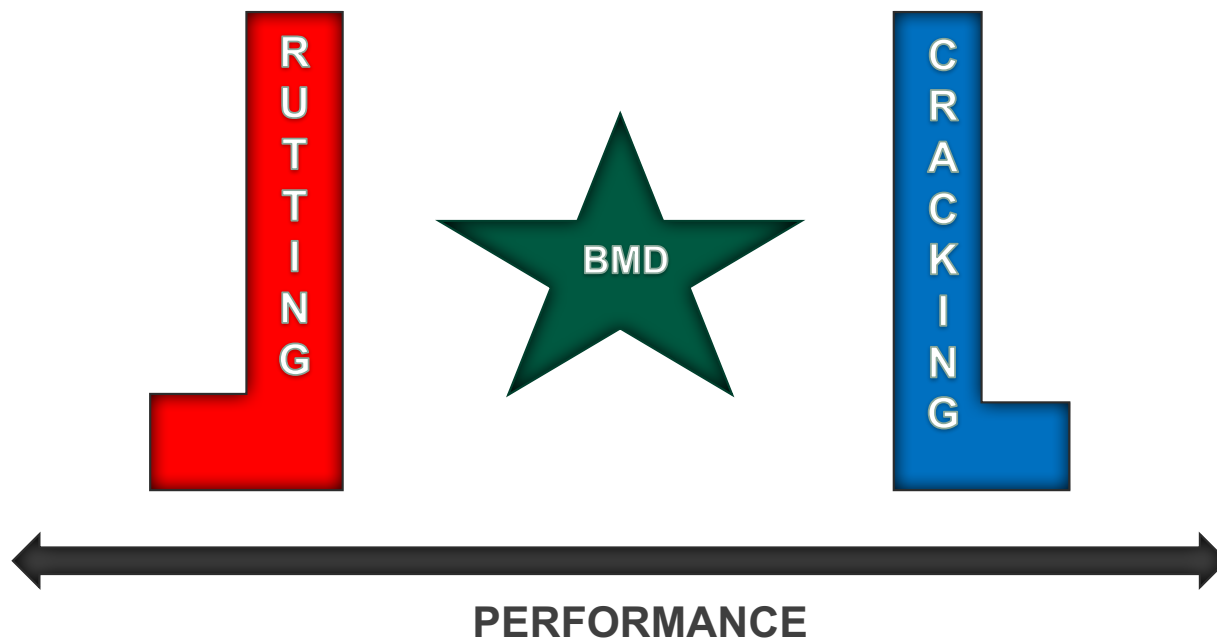


What is the Main Key to Enhancing the Durability of Asphalt Mixtures?

- “**Volume of Effective Binder (Vbe)** is the primary mixture design factor affecting both durability and fatigue cracking resistance.”
 - **$Vbe = VMA - \text{Air Voids}$**



What are the most common performance tests (rutting and cracking) for BMD?



Test Mixtures in the Lab to Help Ensure Field Performance

- Mixtures need to be evaluated in the lab during design to help ensure the required field performance can be achieved.



Lab Test (Hamburg Wheel Tracker)



Lab Test Results



Expected Field Performance

Main Pavement Distresses Observed in the Field

- **Rutting**

- Rutting in asphalt mixture(s) layers (focus of rutting performance testing)



- **Fatigue cracking**

- Bottom-up cracking
- Top-down cracking



- **Reflection Cracking**

- Cracking from underlying cracks/joints



- **Low temperature cracking**

- Shrinkage of mixture due to low temperatures



- **Moisture Damage (Stripping)**



Stability Testing (Rutting)



Rutting Tests

- Rutting can be evaluated with several available tests based on the user preference.



Hamburg Wheel Test (HWT)



Asphalt Pavement Analyzer (APA)



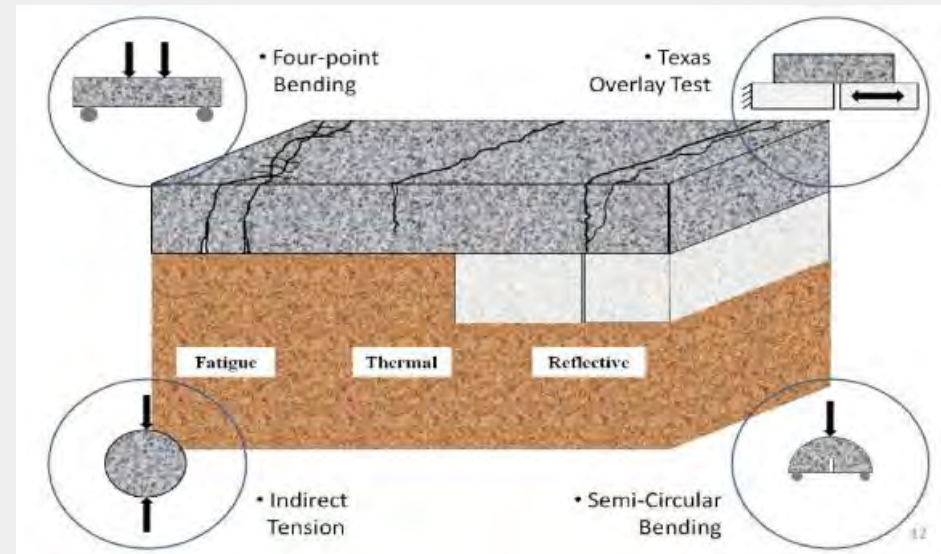
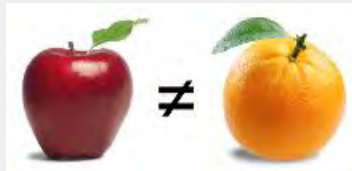
AMPT Flow Number

Durability Testing (Cracking)



First Question for Durability Testing: What is the Anticipated Mode of Distress for Testing?

- Many test are available with each targeting a specific specimen response (i.e., field distress)
- Typical distress modes
 - Fatigue cracking (top down/bottom up)
 - Low temperature (thermal) cracking
 - Reflection (reflective) cracking
- Various empirical and mechanistic tests are available for use.
- Match apples to apples, not apples to oranges!



GOALS

1. MATCH THE TEST TO THE DISTRESS
2. SET APPROPRIATE FAILURE THRESHOLDS

Fatigue (Bottom Up or Top Down) Related Cracking Tests

Bottom Up



Bending Beam Fatigue

Bottom Up



Texas Overlay Test

Bottom Up /
Top Down



SCB
- LTRC – Jc
- IFIT

Bottom Up



**Direct Tension Cyclic
Fatigue, S-VECD**

Thermal Cracking Tests



IDT Creep
Compliance



TSRST



SCB at Low Temp



Disk Shaped Compact
Tension (DCT)

Reflection (Reflective) Cracking Tests



**Disk Shaped Compact
Tension (DCT)**



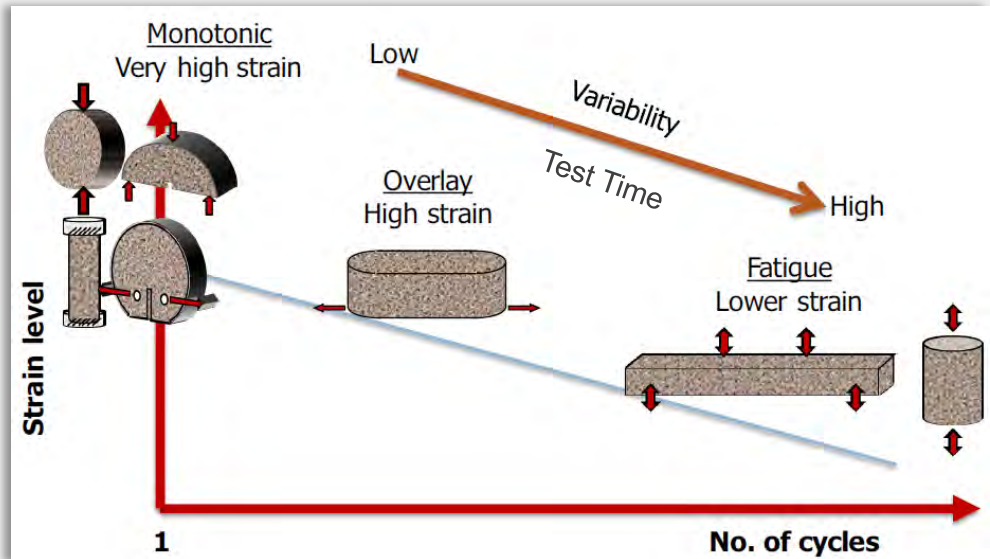
Texas Overlay Test



SCB (IFIT)

Performance Tests

- **Empirical** tests will tend to have monotonic loading + high strains and can be conducted in a shorter time period.
- **Mechanistic** tests will tend to have cyclic loading + low strains and will require a longer test time.
- Each test is developed to **evaluate a certain mixture response**.
- Use caution when trying to relate one test to another (e.g., IFIT vs DCT).

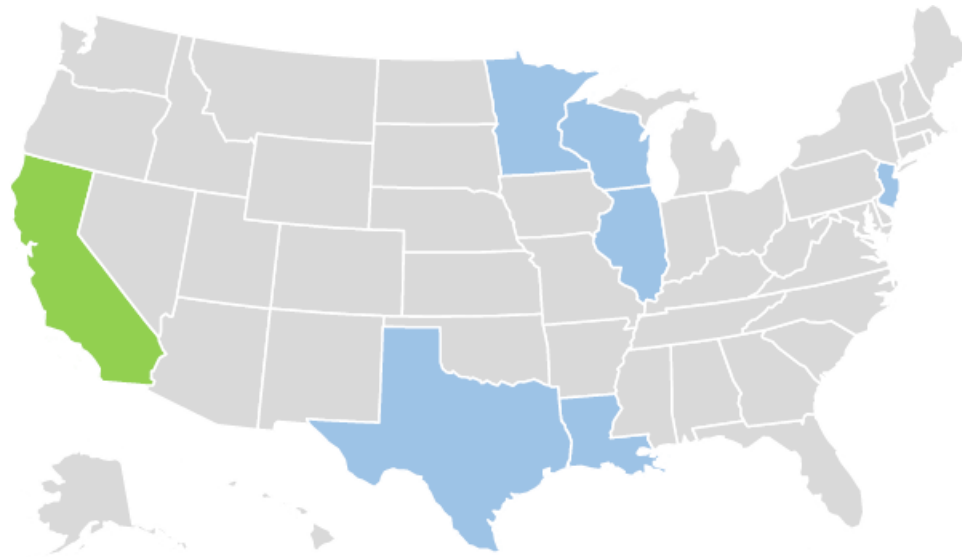


Key Test Considerations

1. Strong relationship to performance
2. Practical: cost, time, complexity
3. Repeatable, reproducible

What is the current national state of practice for BMD?

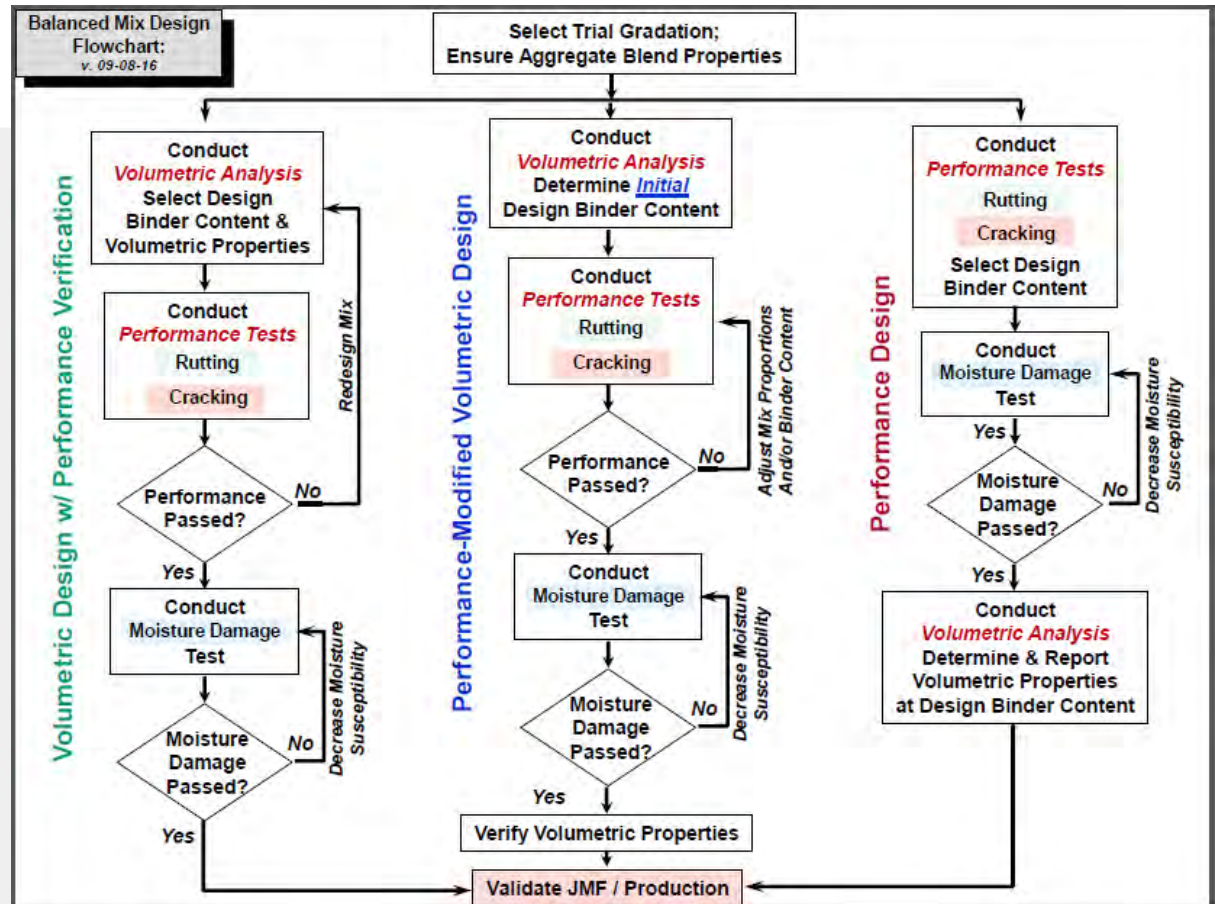
Agency Practices For Balanced Mix Design



BMD Approaches

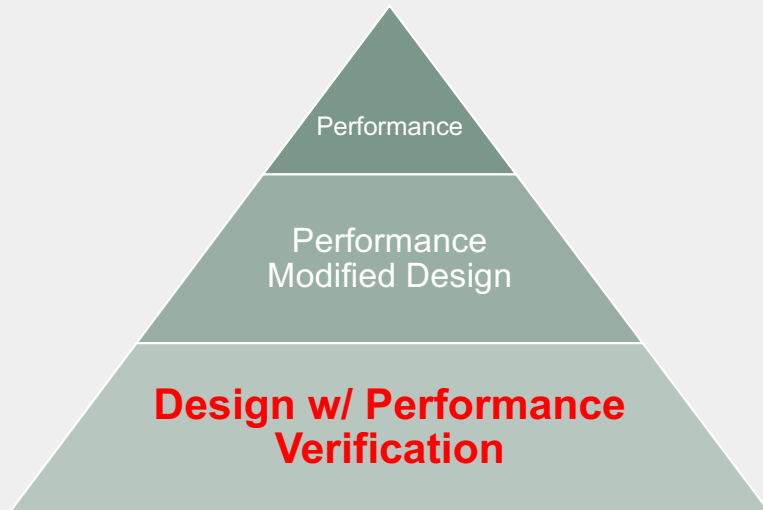
- Three general mix design approaches.

 1. Volumetric Design w/ Performance Verification
 2. Performance Modified Volumetric Design
 3. Performance Design

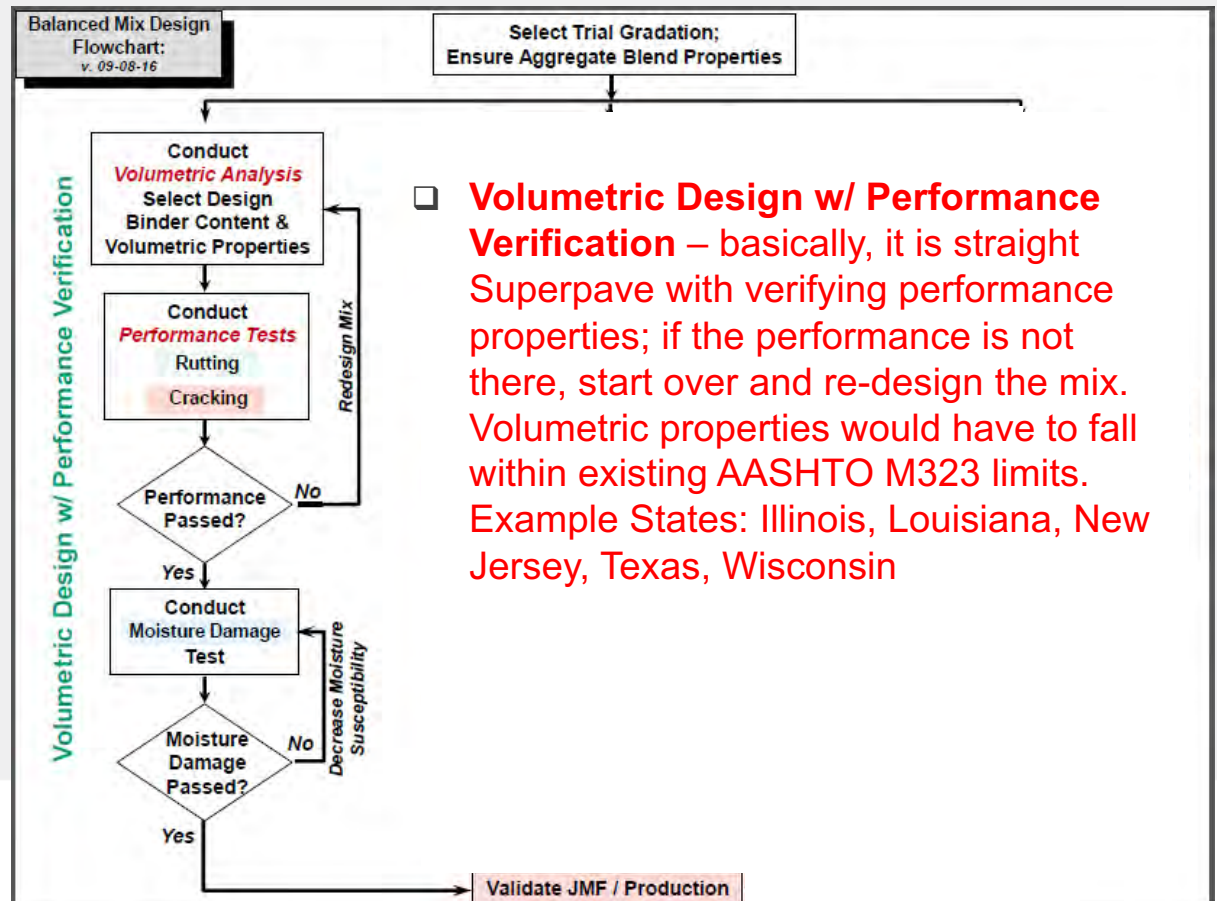


Graphic Developed by Kevin Hall (FHWA BMD Task Force), 2016

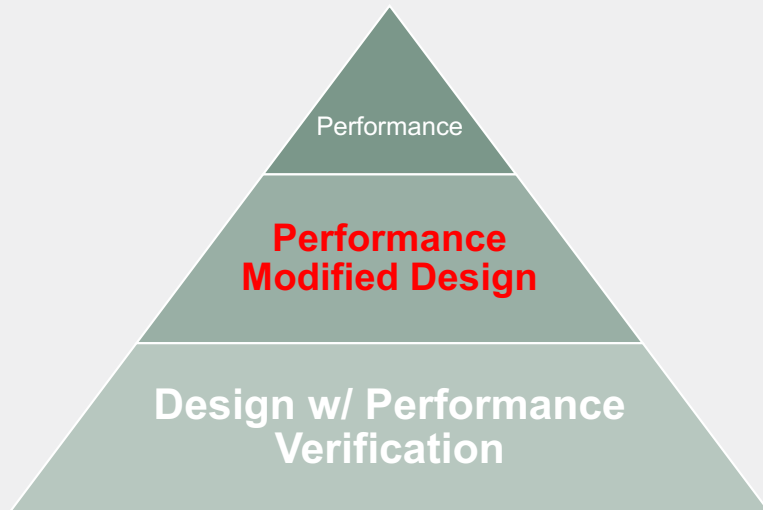
Volumetric Design w/ Performance Verification



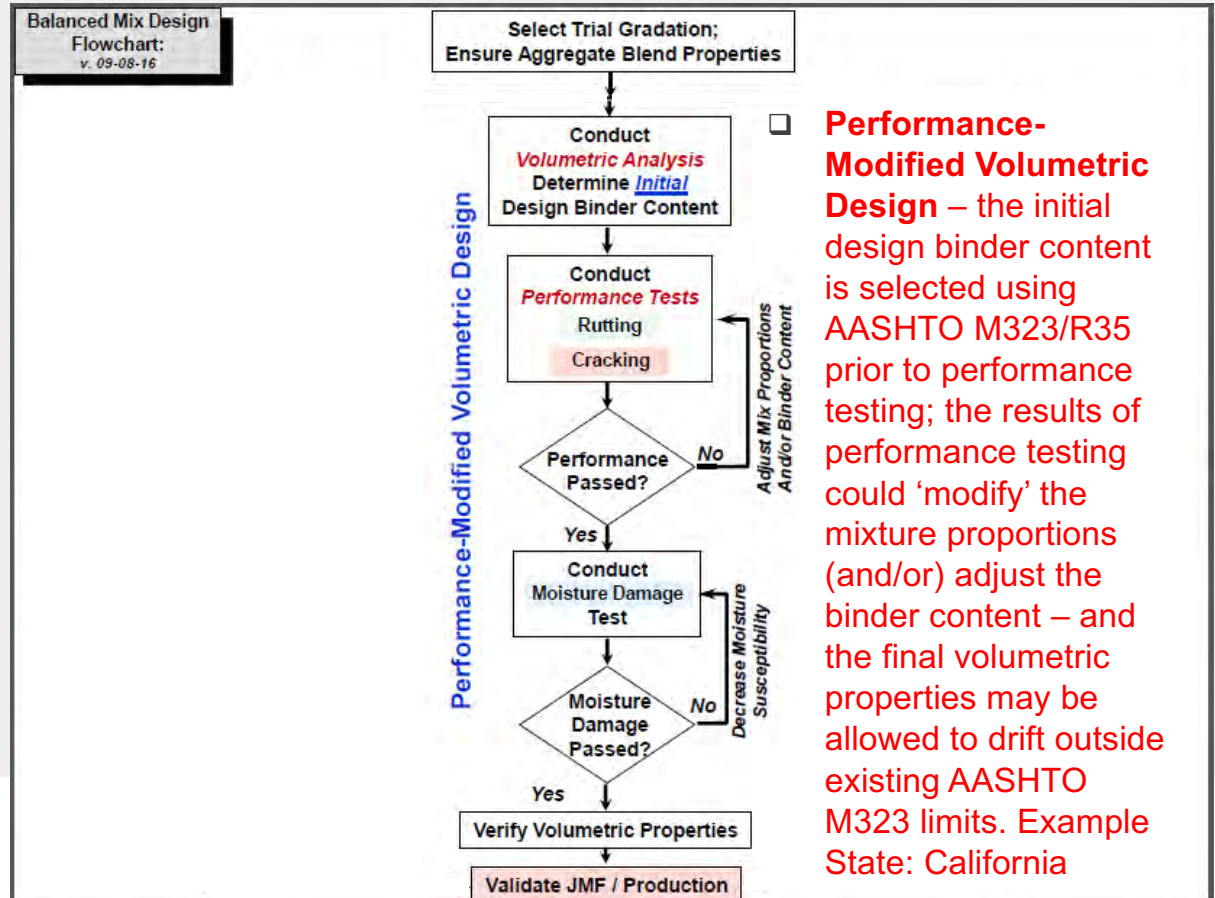
Innovation Potential = Very Low



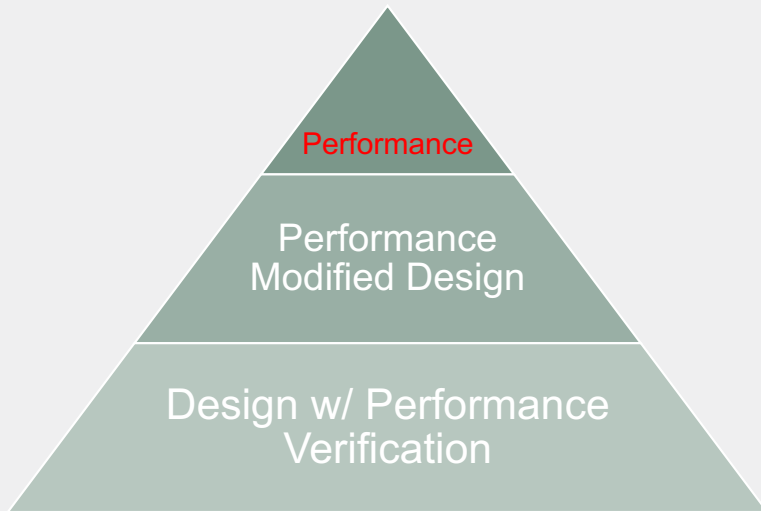
Performance Modified Volumetric Design



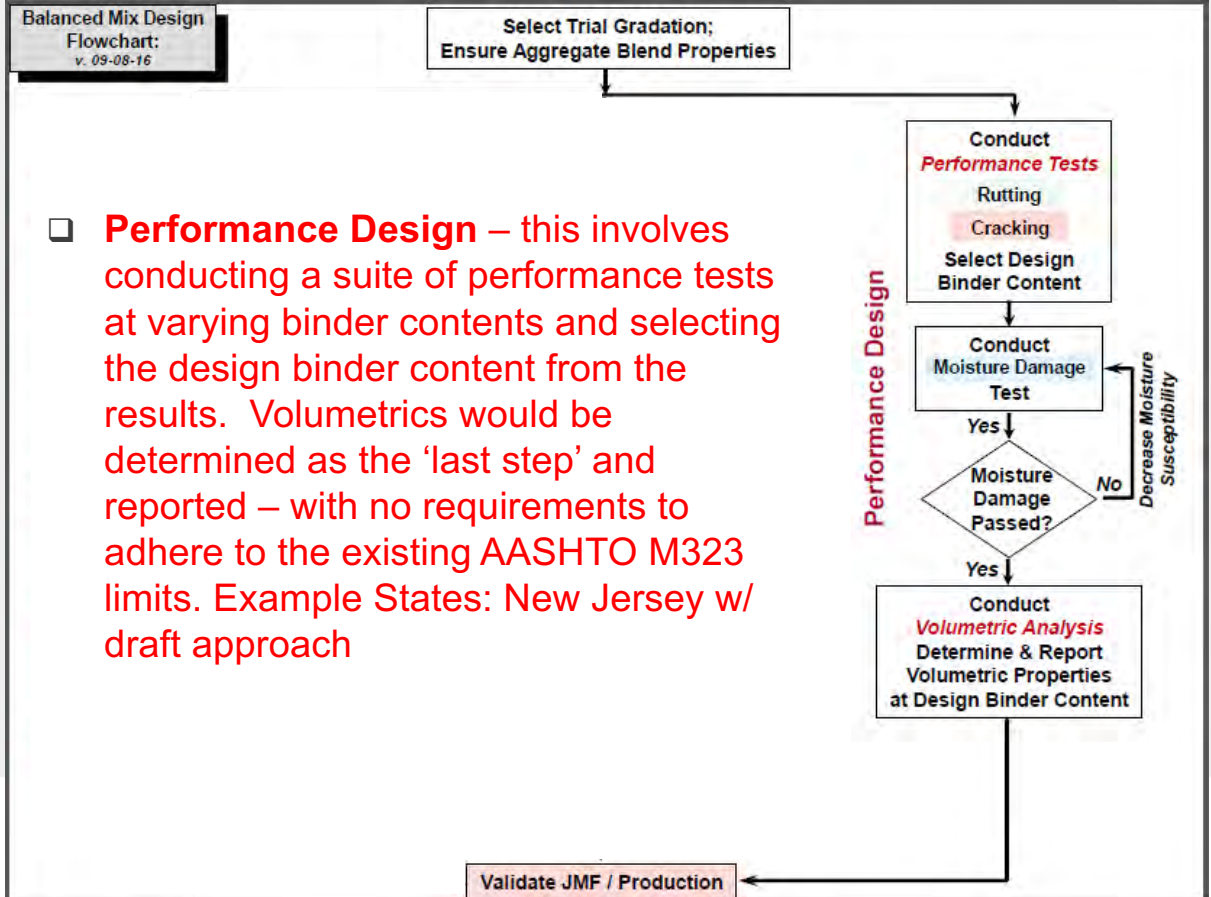
Innovation Potential = Low



Performance Design



*Innovation Potential =
Medium / High*



What Typically Drives a State Agency Practice?

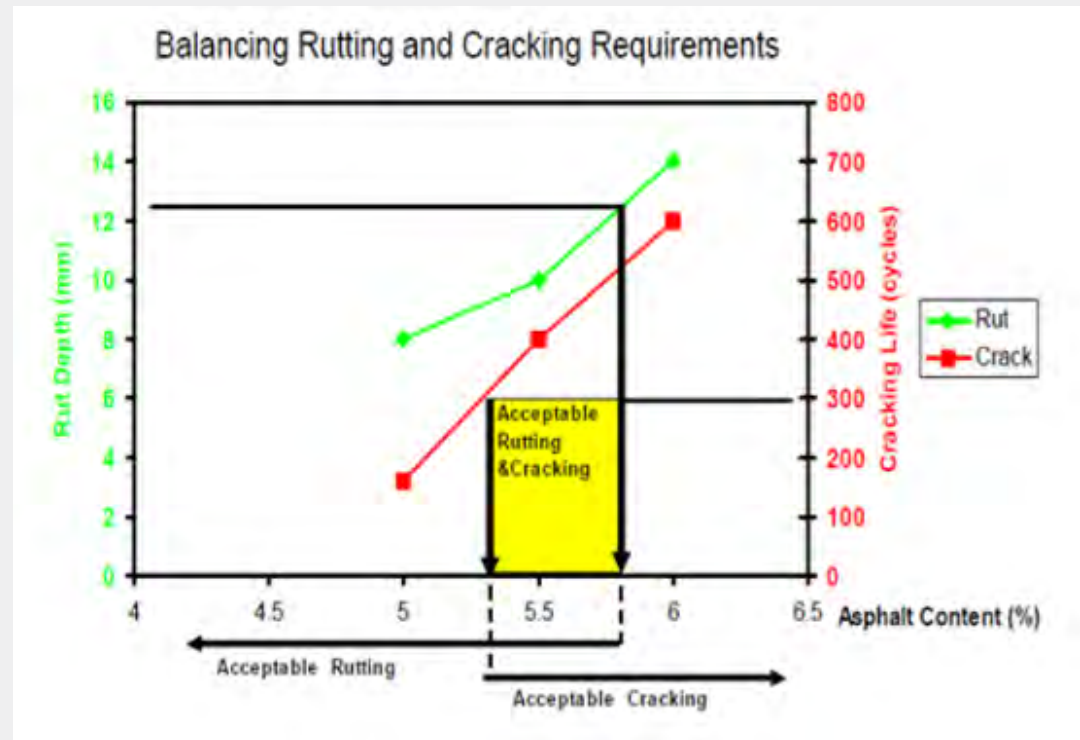
- SHAs are selecting different performance tests.
- Variance is driven by 1) different pavement distress considerations (e.g., thermal cracking in Minnesota versus top-down cracking in Florida) and 2) intended mix application or mix component of interest (e.g., specialty mixes or high recycle mixes).
- BMD approaches vary, and will likely continue to vary, in the future.
 - Not unexpected...
 - ✦ How many states currently use AASHTO M323 without any modification? Not many!



BMD Basic Example – Volumetric Design w/ Performance Verification

- **Texas DOT**

- Volumetric design conducted
- Hamburg Wheel Tracking Test (HWTT) AASHTO T 324
- Overlay Tester (OT) Tex-248-F
- Three asphalt binder contents are used: optimum, optimum +0.5%, and optimum -0.5%.
- The HWTT specimens are short-term conditioned.
- The OT specimens are long-term conditioned.



Within this acceptable range (5.3 to 5.8 percent), the mixture at the selected asphalt content must meet the Superpave volumetric criteria.

Ongoing National Research: NCHRP Project 20-07/Task 406

- **Development of a Framework for Balanced Asphalt Mixture Design**
 - 1 yr. / 100k Project, Started May 2017
- The objective of this research is to develop a framework that addresses alternate approaches to devise and implement balanced mix design procedures incorporating performance testing and criteria.
- **The framework shall be presented in the format of an AASHTO recommended practice and shall encompass a wide variety of testing procedures and criteria.**

Framework for Balanced Mix Design NCHRP 20-07/Task 406



Ongoing State DOT Research

- BMD is a very “hot” topic nationally!
- Various State DOTs have current research activities focused on BMD related activities


State DOT	Research Title
California	Simplified Performance Based Specifications for Long Life AC Pavements
Idaho	Development and Evaluation of Performance Measures to Augment Asphalt Mix Design in Idaho
Indiana	Performance Balanced Mix Designs for Indiana's Asphalt Pavements
Minnesota	Balanced Design of Asphalt Mixtures
Texas	Develop Guidelines and Design Program for Hot-Mix Asphalts Containing RAP, RAS, and Other Additives through a Balanced Mix Design Process
Wisconsin	<ol style="list-style-type: none"> 1. Analysis and Feasibility of Asphalt Pavement Performance-Based Testing Specifications 2. Regressing Air Voids for Balanced HMA Mix Design



How does a BMD compare with a volumetric mix design?

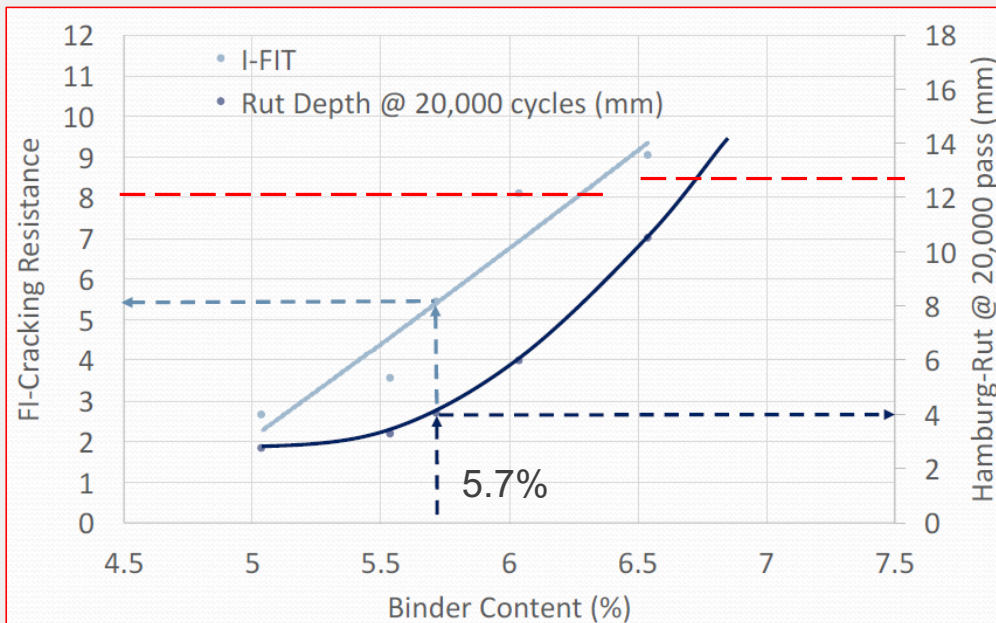
Balanced Mix Design is Really Nothing Totally New!

- Many similarities with older design approaches.

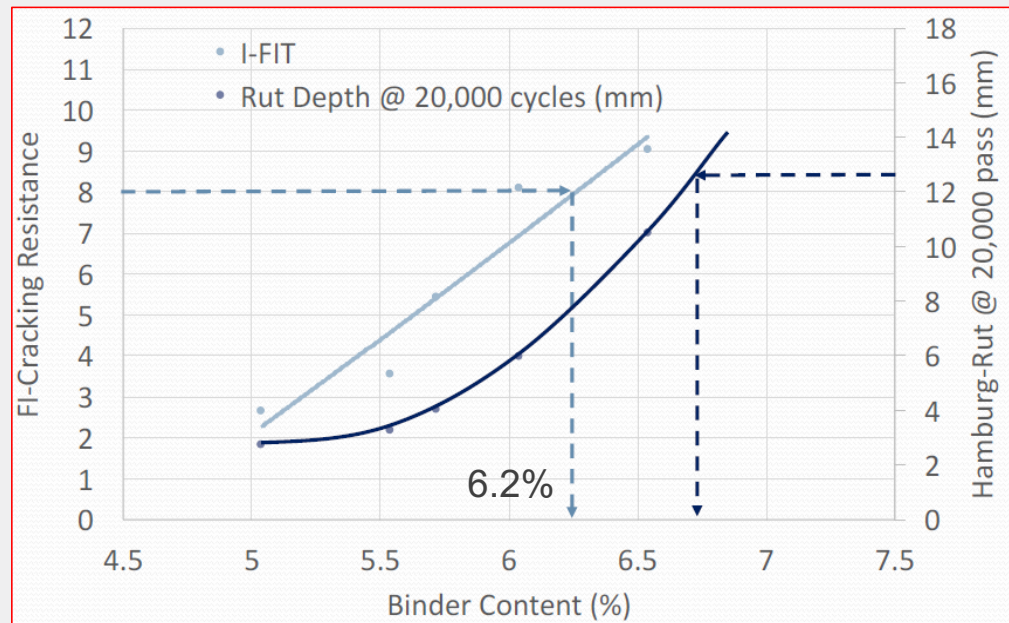
Step	Marshall	Hveem 	Balanced Mix Design
Select Asphalt Binder	YES	YES* (CKE for %)	YES
Select Virgin Aggregate	YES	YES	YES
Select Recycle Content	YES	YES	YES
Compact Specimens at a Range of Binder Contents	YES	YES	YES
Calculate Volumetric Properties	YES	YES	YES
Conduct Stability Performance Testing	YES (Marshall Stability)	YES (Hveem Stabilometer)	YES (User Preference)
Conduct "Durability" Performance Testing	YES (Marshall Flow)	YES (Hveem Cohesimeter)	YES (User Preference for Target Distress)
Evaluation Performance Tests Against Developed Mix Specific Criteria	YES	YES	YES
Select Optimum Binder Content	YES	YES	YES
Determine Volumetric Properties at Optimum Binder Content	YES	YES	YES
Evaluate Moisture Susceptibility at Optimum Binder Content	YES	YES	YES
Control Mixture During Production	YES (Volumetrics)	YES (Volumetrics)	YES (Volumetrics and/or Performance Tests)

Volumetric Mix Design vs Balanced Mix Design (*Example*)

VOLUMETRIC



BALANCED

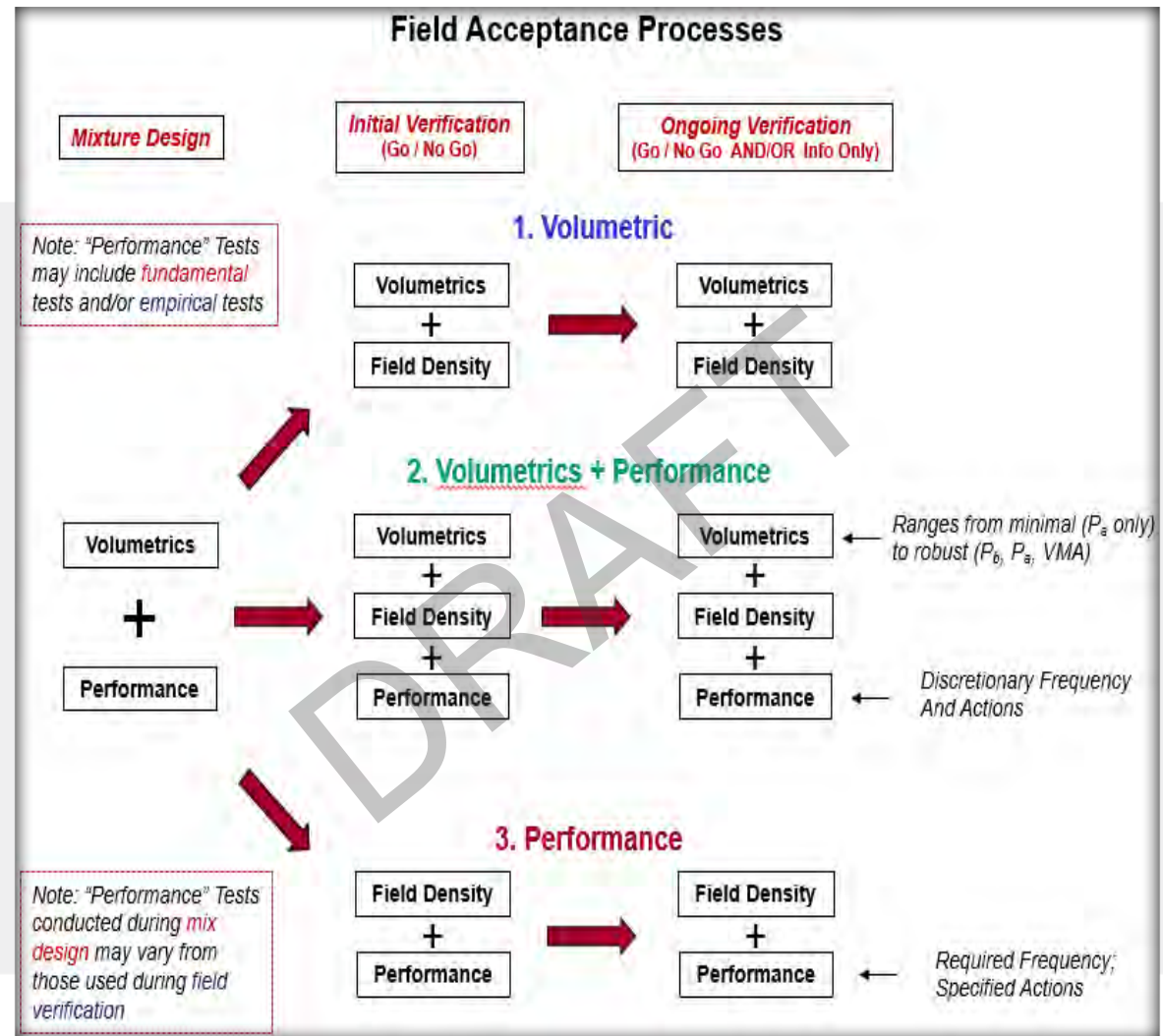


Note: Example for Illustration Purposes.

What about acceptance testing with a BMD approach?

BMD Field Acceptance - Approaches

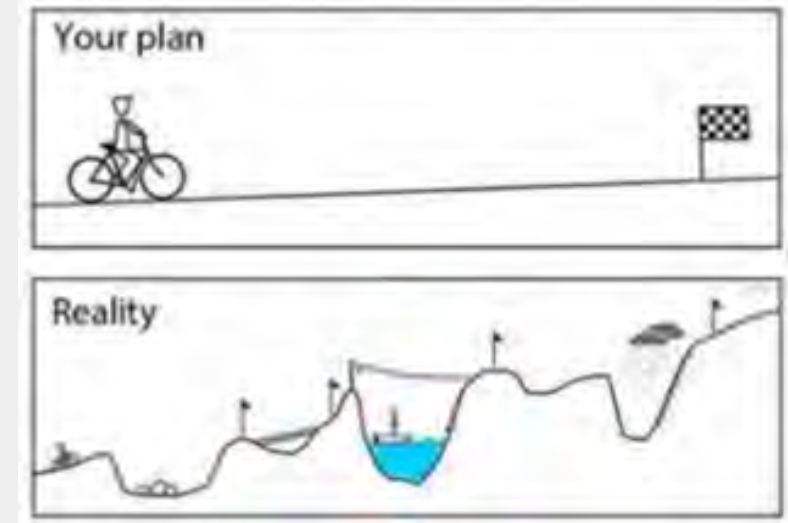
- **Any** designed mixture **must be produced and controlled to help ensure acceptable field performance.**
- Three general field acceptance approaches.
 1. **Volumetric**
 2. **Volumetrics + Performance**
 3. **Performance**



What's the future of BMD?

The Path Forward for Balanced Mix Design

- Long term effort with ups/downs, but **we must start now.**
- Recognize the need and move incrementally in the appropriate direction to limit risk of mix performance issues.
- Utilize **available, proven** approaches to find **effective, implementable** solutions.
- Completion of 20-07 Task 406 and the developed AASHTO recommended practice will aid use / implementation.



Thank You / Questions

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