SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Balanced Mix Design (BMD) for Asphalt Mixtures

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Oldcastle Materials

September 20, 2016

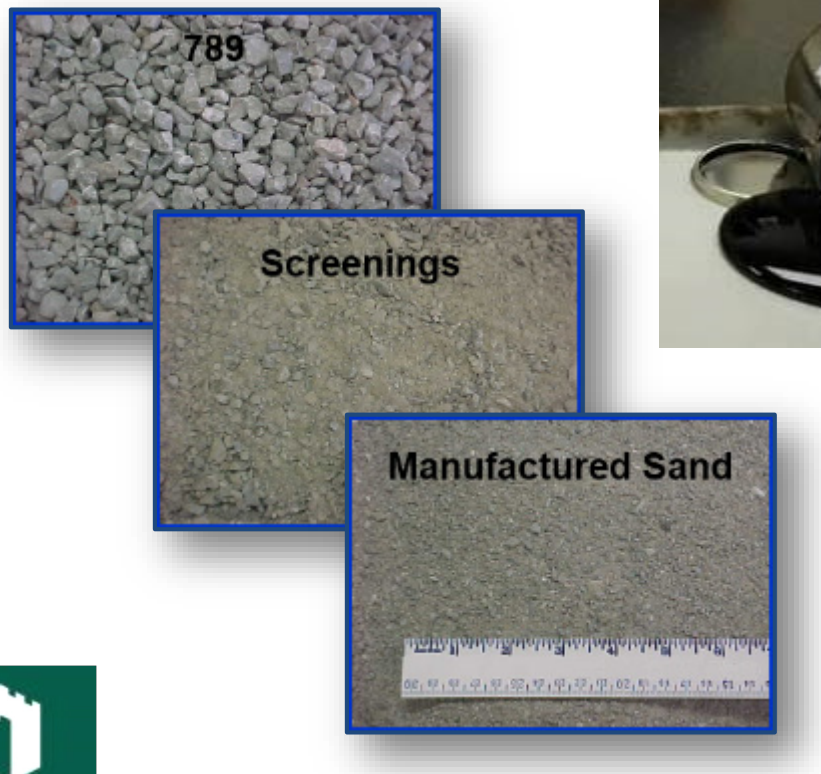
U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Discussion Items

- Need for Balanced Mix Design
- Define Balanced Mix Design
- Review FHWA Balanced Mix Design Task Force Efforts
  - Current State Agency Practice
  - NCHRP Problem Statement Development
  - Technical Brief Development on Balanced Mix Design

Need for Balanced Mix Design



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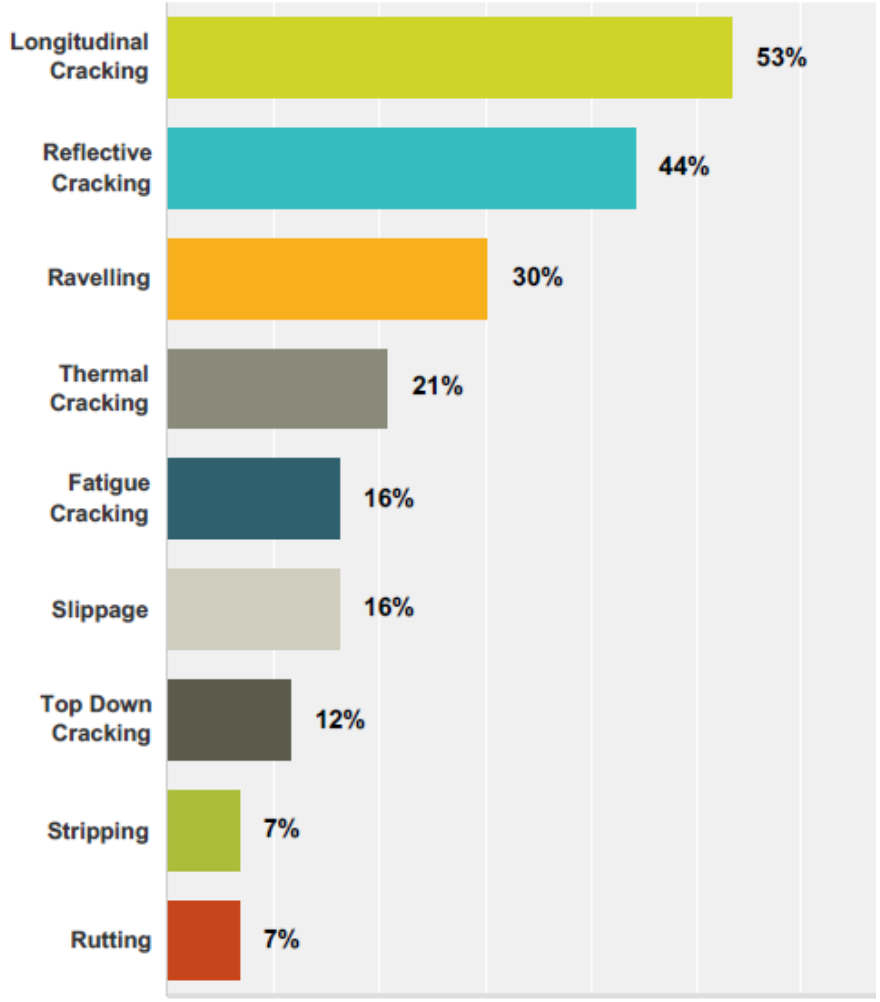
What Type Distress Is Occurring?

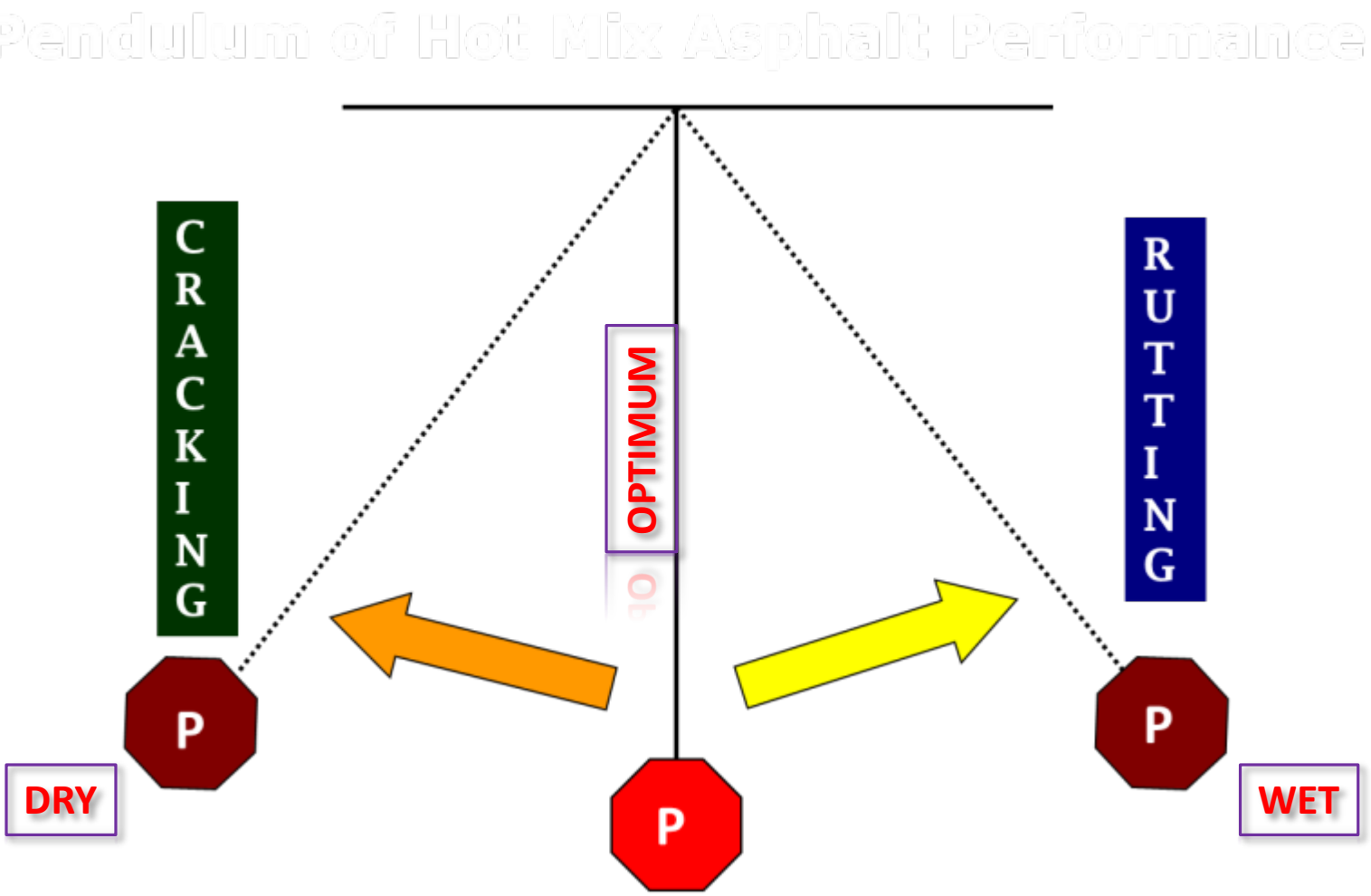
Oldcastle Survey Question:
Within the past 5 years, what type of mix performance related distress has been most evident in your mixes?

~40 companies responding from ~30 states

- Most reported distresses are related to mix durability.



Pendulum of Asphalt Mix Performance



Binder Content – Design vs. Optimum (There is a difference!)

- Design and optimum are often used interchangeably
  - However, they mean two different things
- There can be many design binder contents for a mix, but only one truly optimum
- Optimum indicates the best binder content based on intended application, performance requirements/needs, and ultimately economics
- Goal is to get as close as possible to the true optimum for the mix

History of Mix Design

1890
- **Barber Asphalt Paving Company**
- Asphalt cement 12 to 15% / Sand 70 to 83% / Pulverized carbonite of lime 5 to 15%

1905
- **Clifford Richardson, New York Testing Company**
- Surface sand mix: 100% passing No. 10, 15% passing No. 200, 9 to 14% asphalt
- Asphaltic concrete for lower layers, VMA terminology used, 2.2% more VMA than current day mixes or ~0.9% higher binder content

1920s
- **Hubbard Field Method** (Charles Hubbard and Frederick Field)
- Sand asphalt design
- 30 blow, 6" diameter **with compression test (performance)** asphaltic concrete design (Modified HF Method)

Stability

1927
- **Francis Hveem** (Caltrans)
- Surface area factors used to determine binder content; **Hveem stabilometer and cohesionmeter** used
- Air voids not used initially, mixes generally drier relative to others, fatigue cracking an issue

Stability + Durability

1943
- **Bruce Marshall**, Mississippi Highway Department
- Refined Hubbard Field method, standard compaction energy with drop hammer
- Initially, only used air voids and VFA, VMA added in 1962; **stability and flow utilized**

Stability + Durability

1993
- **Superpave**
- Level 1 (volumetric)
- Level 2 and 3 (performance based, but **never implemented**)

BINDER CONTENT LOWER

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

Balanced Mix Design Task Force Development History

- Concern nationally of early age durability related performance issues.
- Many states have started the process of "performance testing" during mix design and/or production to help ensure mix performance.
  - Process has been referred to as a balanced mix design approach.
- **National Pavement Implementation Executive Task Group (PIETG)** highlighted BMD as needed focus area

PIETG

- The PIETG is focused on the strategic program level challenges and opportunities in the deployment of pavement technologies.
- Focus areas include:
  - ***Pavement Design and Analysis;***
  - ***Pavement Materials and Quality Assurance;***
  - Pavement Surface Characteristics;
  - Construction Technology;
  - Pavement Sustainability;
  - Technical Capacity; and
  - Field Support/Technical Assistance.

Pavement Implementation Executive Task Group (PIETG)

FHWA		
John Bukowski	Materials Team Leader	FHWA
Christopher Wagner	Pavment and Materials Tech. Srvs. Team Leader	
Gina Ahlstrom	Pavement Design and Analysis Team Leader	
Jeff Withee	Pavement Materials Engineer	
Mark Swanlund	Infrastructure R&D Program Coordinator	
Bryan Cawley	Construction Mgmt. Team Leader	
Stephen Gaj	Asset Mgmt. Team Leader	
Hari Kalla	Director, Office of Asset Mgmt., Pavement & Construction	
INDUSTRY		
Mike Acott	President	NAPA
Audrey Copeland	VP, Engineeering, Tech. and Research	NAPA (attendee)
Gerald Voigt	President/CEO	ACPA
Leif Wathne	VP, Highways and Federal Affairs	ACPA (alternate)
Jim Duit	President	Duit Construction Co.
Dave Howard	President/CEO	Koss Construction
Ron Sines	VP - Asphalt Performance	Oldcastle Materials
Jay Winford	President	Prairie Contractors, Inc.
DOTs		
Carlos Braceras	Executive Director	Utah DOT
Dave Huft	Research Program Mgr.	South Dakota DOT
Richard Tetreault	Deputy Secretary	Vermont Agency of Transportation
Russell McMurry	Commissioner	Georgia DOT
Garrett Moore	Chief Engineer	Virginia DOT
ACADEMIA		
Peter Taylor	Associate Director	Iowa State University
Kevin Hall	Professor and Head	University of Arkansas (CE)
David Newcomb	Senior Research Scientist	Texas A&M Transportation Institute
Paul Tikalsky	Dean of Engineering	Oklahoma State University

BMD Task Force Formed at September 2015 ETG MTG

Excerpt on Balanced Mix Design Task Force formation
from Asphalt Mix ETG Meeting Report – Oklahoma City, OK – September 2015

Under the second area of interest, the Pavement Implementation Executive Task Group asked FHWA to create a task group on balanced mix design. Bukowski suggested creating a Task Group from not only ETG members but also friends of the ETG of 6-8 individuals to start by defining balanced mix design, goals, and how to achieve those goals. Hall noted that the Executive Group is looking for solutions, tools that can be done immediately and not for five years of research. For example, how to address cracking and what can be done at the mix design stage to minimize cracking and how to provide a state with a guidance to characterize cracking. It is not about a specific cracking test rather if a state already have a cracking test how would the state use the test at the design stage to balance the mix and minimize cracking. Bukowski mentioned that a discussion also on balanced mix design took place during the SOM meeting in Pittsburg. He noted that the new ETG Task Group needs to formulate suggested guidance about balanced mix design and provide a clear direction based on the various available methods and information. Hall suggested to think about the direction as almost like a road map for balanced mix design (where we want to be and how to get there). Hall noted that ultimately we need fundamental tests and analysis but what can be done in the meantime as part of the road map (what is available and what is not available). Musselman recommended the approach needs to stay practical.

BMD Task Force Membership

Name	Affilation	Category	e-mail
Dave Newcomb	Texas Transportation Institute	Academia/Research	d-newcomb@ttimail.tamu.edu
John Haddock	Purdue University	Academia/Research	jhaddock@purdue.edu
Kevin Hall	University of Arkansas	Academia/Research	kdhall@uark.edu
Louay Mohammad	Louisiana State University	Academia/Research	Louaym@Lsu.edu
Brian Pfeifer	Illinois DOT	Agency	Brian.Pfeifer@illinois.gov
Bryan Engstrom	Massachusetts DOT	Agency	Brian.Pfeifer@illinois.gov
Charlie Pan	Nevada DOT	Agency	cpan@dot.state.nv.us
Curt Turgeon	Minnesota DOT	Agency	curt.turgeon@state.mn.us
Derek Nener-Plante	Maine DOT	Agency	derek.nener-plante@maine.gov
Eliana Carlson	Connecticut DOT	Agency	Eliana.Carlson@CT.gov
Howard Anderson	Utah DOT	Agency	handerson@utah.gov
Oak Metcalfe	Montana DOT	Agency	rmetcalfe@mt.gov
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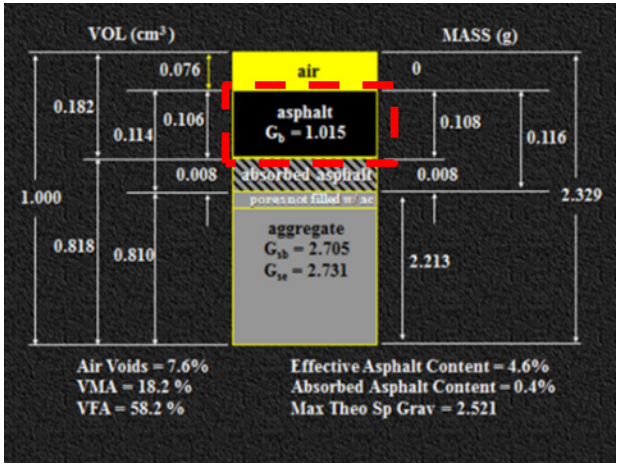
Shane Buchanan	Oldcastle Materials	Industry	sbuchanan@oldcastlematerials.com
Anne Holt	Ontario Ministry of Transportation	Provincial Agency	Anne.Holt@ontario.ca
Randy West	NCAT	Research	westran@auburn.edu

BMD Task Force Goals and Focus Areas

- Define Balanced Mix Design
- Determine the current “state of practice” of BMD
- Present approaches/concepts for immediate use
- Recommend future needs (potential research) to advance BMD approaches
- Disseminate information

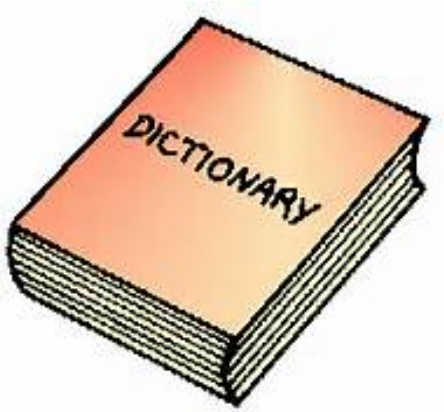


BMD Task Force Work Items

- **Completed**
  - Definition of Balanced Mix Design
  - Survey of Agency Current Practice
    - Laboratory Balanced Mix Design Protocols
    - Field Acceptance Protocols
  - Research Problem Statement (RPS) Submitted to AASHTO)

- **Current**
  - FHWA Technical Brief on Balanced Mix Design
    - Draft prepared, reviewed and being revised

Balanced Mix Design Definition



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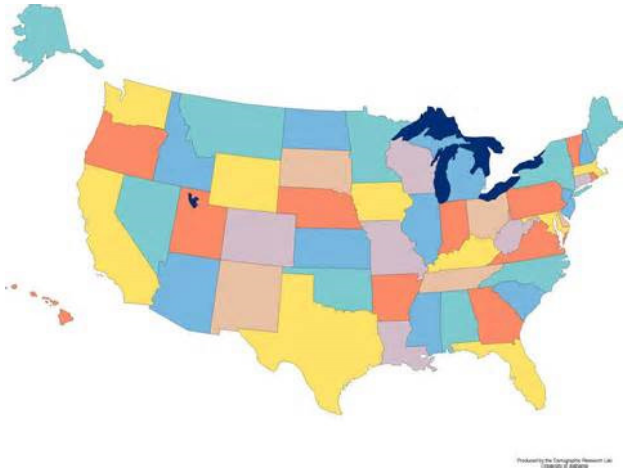
Balanced Mix Design Definition

- ***"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."***

- ***Basically, it consists of designing the mix for an intended application and service requirement.***

Agency Practices Related to BMD



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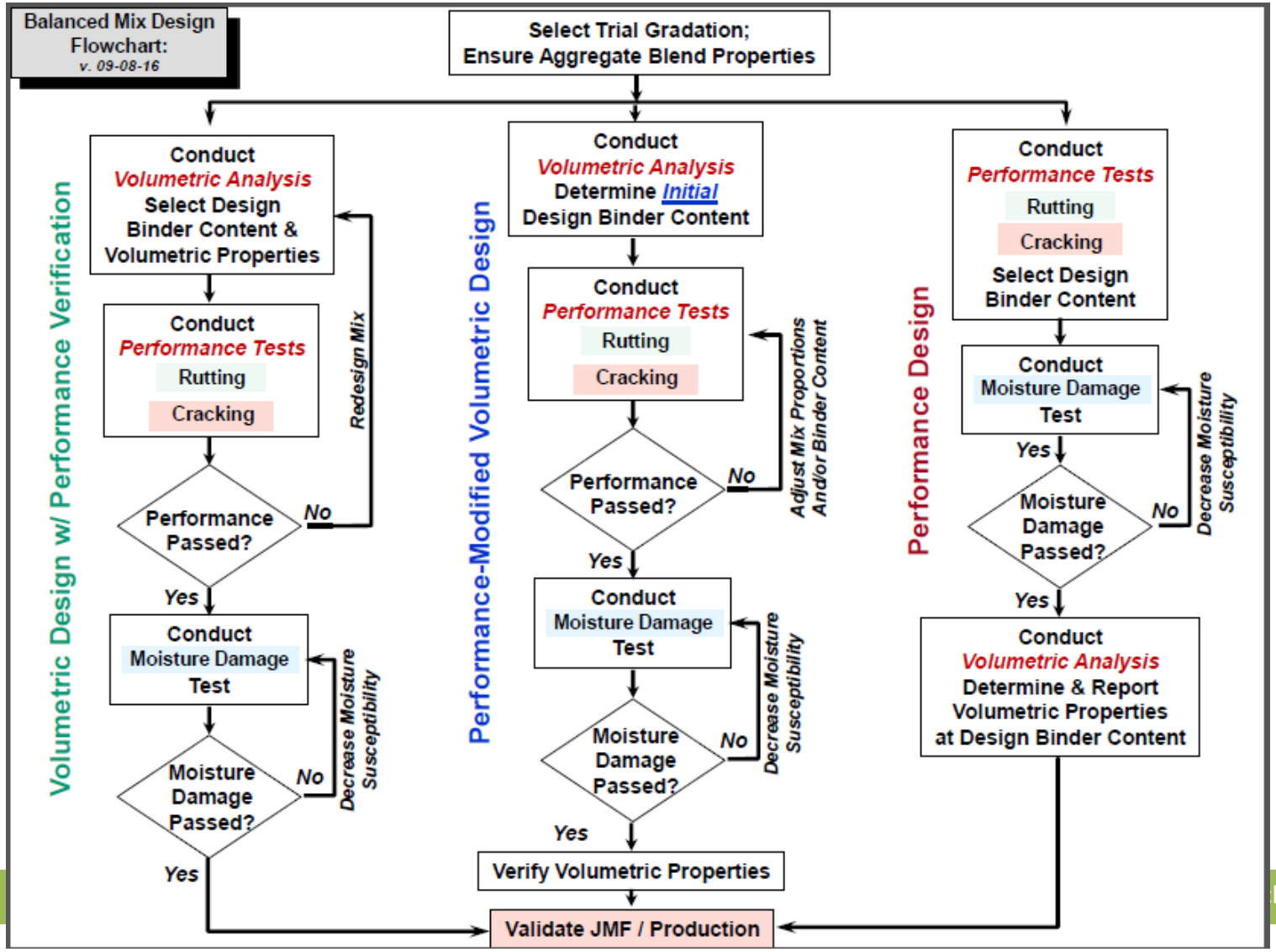
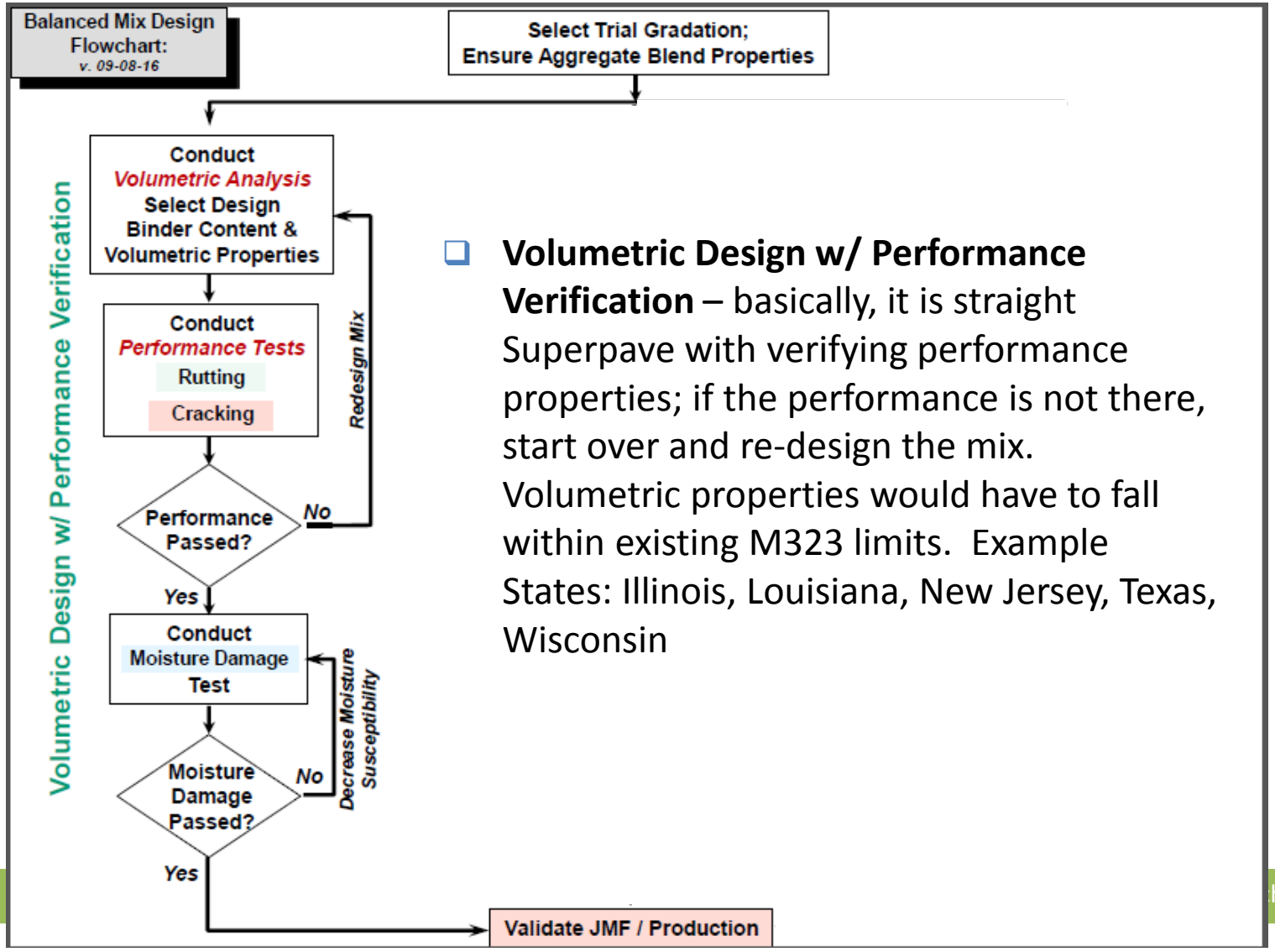
Agency Approaches – 3 Main Approaches Identified

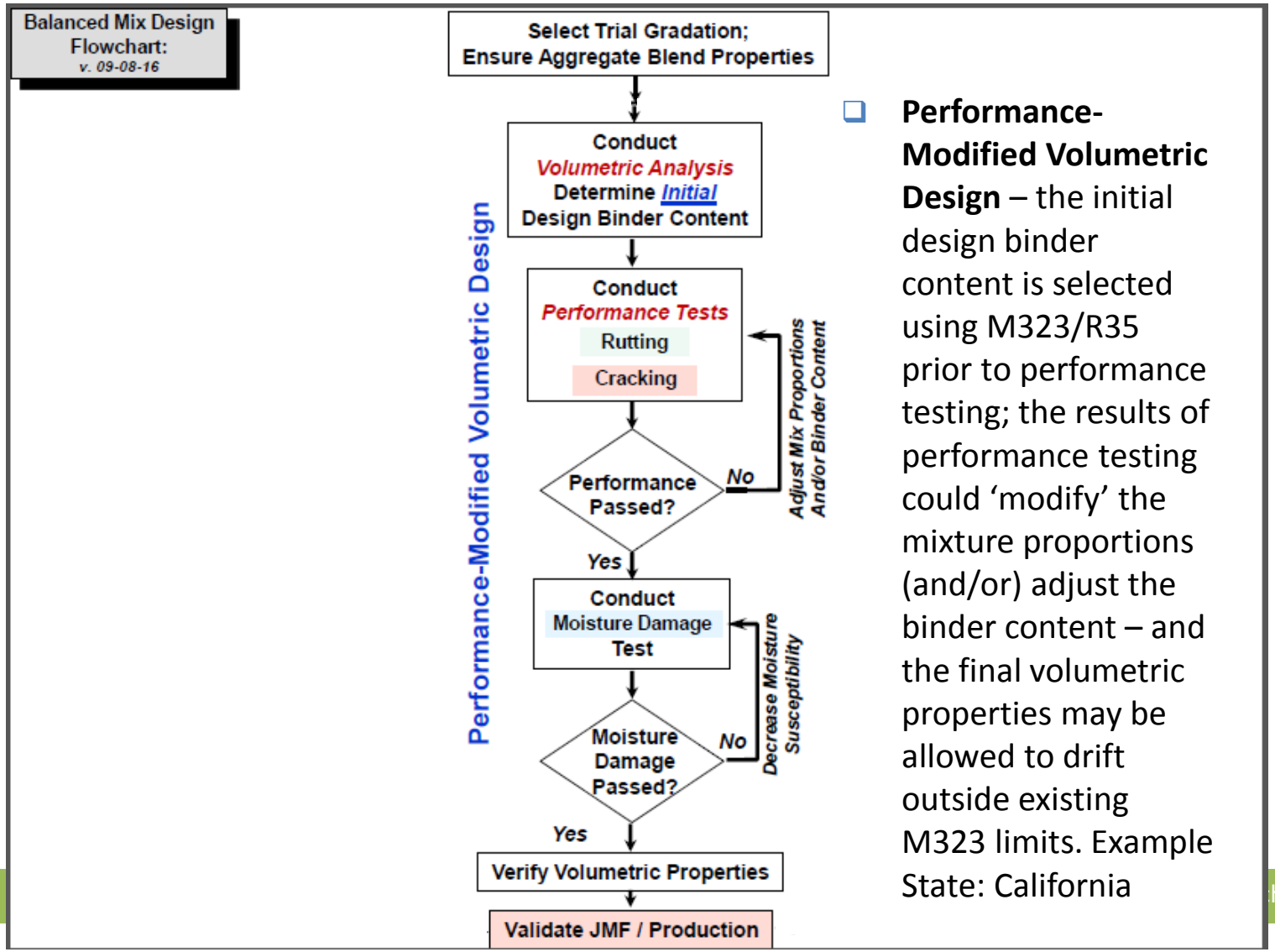


Volumetric Design w/ Performance Verification



- **Volumetric Design w/ Performance Verification** – basically, it is straight Superpave with verifying performance properties; if the performance is not there, start over and re-design the mix. Volumetric properties would have to fall within existing M323 limits. Example States: Illinois, Louisiana, New Jersey, Texas, Wisconsin

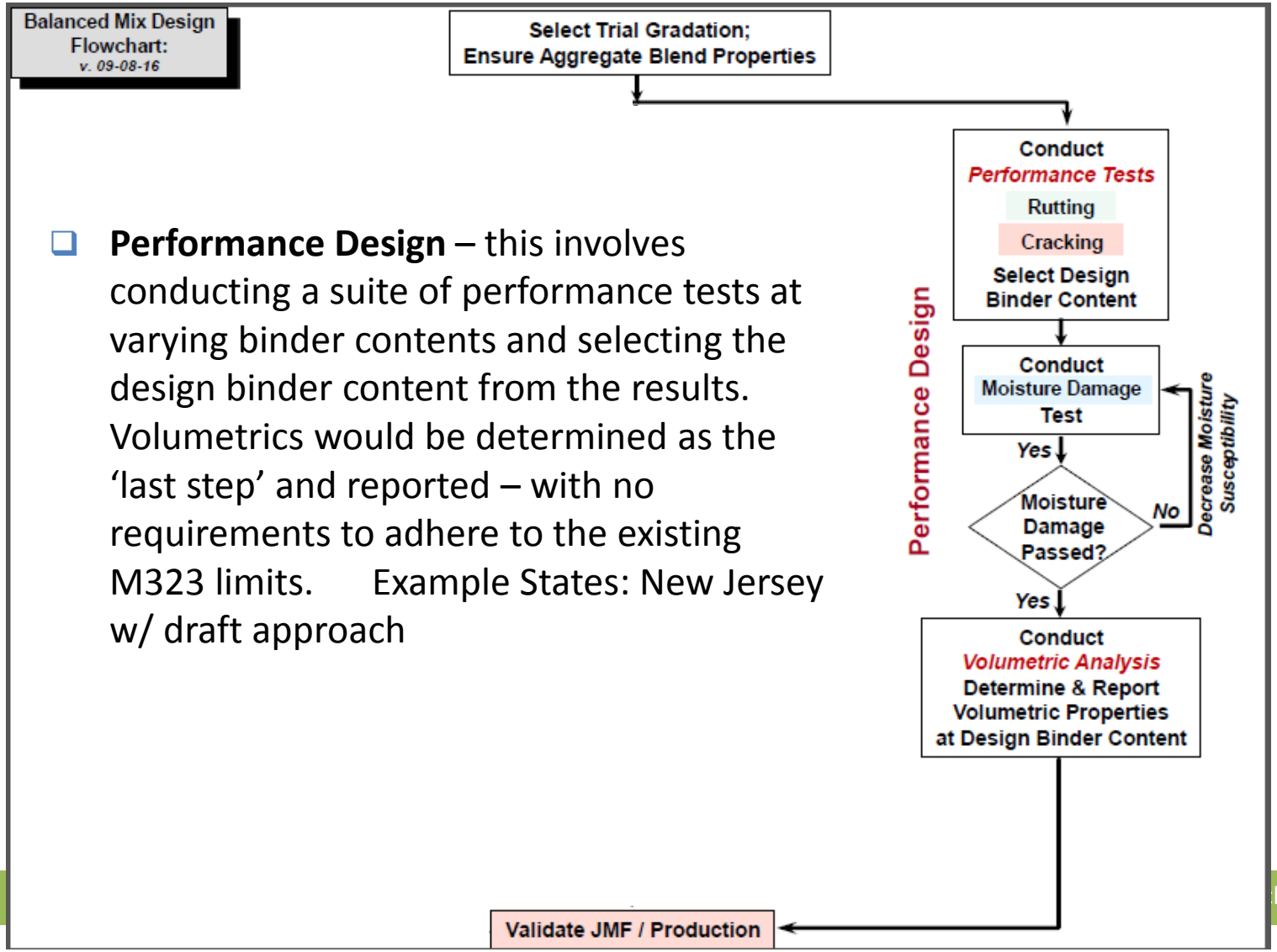
Performance Modified Volumetric Design



- **Performance-Modified Volumetric Design** – the initial design binder content is selected using M323/R35 prior to performance testing; the results of performance testing could 'modify' the mixture proportions (and/or) adjust the binder content – and the final volumetric properties may be allowed to drift outside existing M323 limits. Example State: California

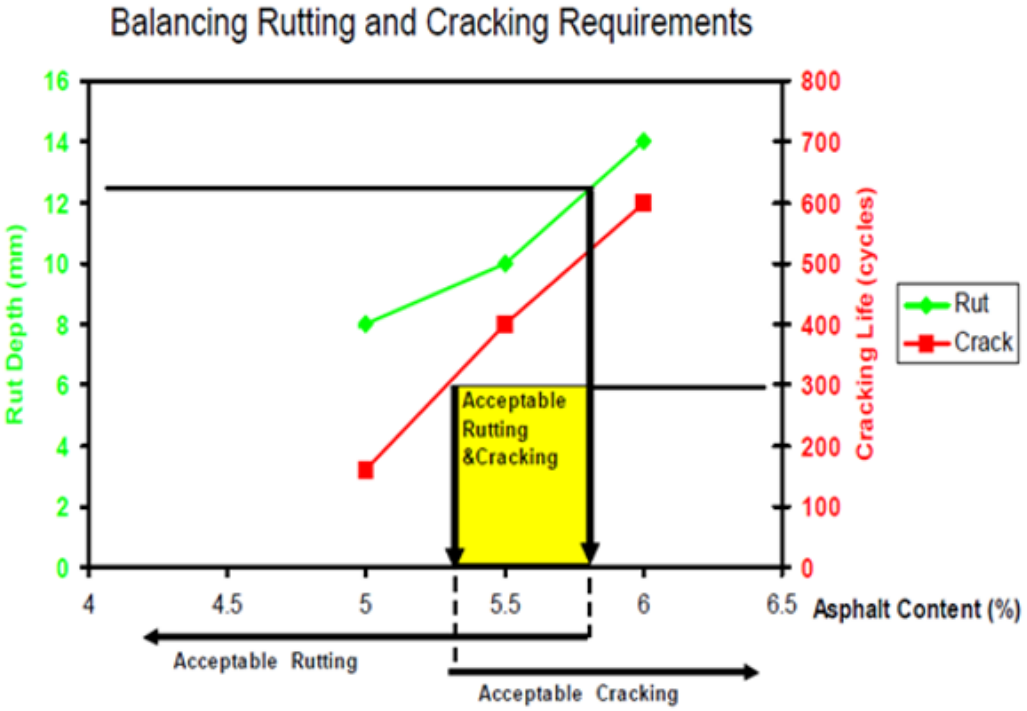
Performance Design

- **Performance Design** – this involves conducting a suite of performance tests at varying binder contents and selecting the design binder content from the results. Volumetrics would be determined as the 'last step' and reported – with no requirements to adhere to the existing M323 limits. Example States: New Jersey w/ draft approach



BMD Basic Example – Volumetric Design w/ Performance Verification

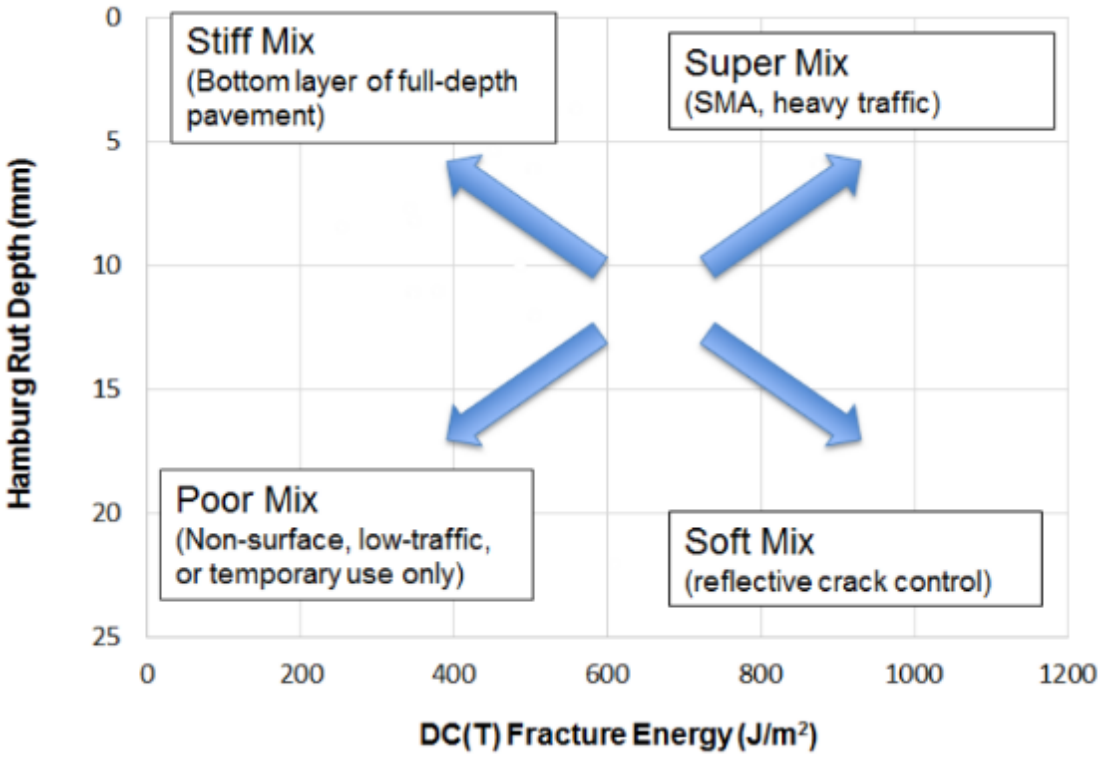
- **Texas DOT**
  - Volumetric design conducted
  - Hamburg Wheel Tracking Test (HWTT) AASHTO T 324
  - Overlay Tester (OT) Tex-248-F
  - Three asphalt binder contents are used: optimum, optimum +0.5%, and optimum -0.5%.
  - The HWTT specimens are short-term conditioned.
  - The OT specimens are long-term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



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

Using Performance Testing to Better Understand Your Mixes

- Performance space diagrams show the performance of a mix related to multiple tests
- Allows the mix designer to visualize the mix performance and how to engineer the mix to provide the desired performance
- Illustrates the impact of varying mix factors on performance.



From: Performance-Space Diagram for the Evaluation of High and Low Temperature Asphalt Mixture Performance, Buttlar et al, AAPT 2016

Need for Production Verification

Design

Optimize

- Local materials use, recycle, additives, cost, appropriate binder content
- Specific site/end use

Establish

- Performance criteria
- Potential surrogate test correlation
- Volumetric property baseline

Production

Verify

- QC testing
- Volumetrics comparison to baseline
- Surrogate (“Quick”) tests
- Performance tests at “x” frequency

BMD TF Work Products

Research Problem Statement

+

FHWA Technical Brief

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Research Problem Statement

- RPS prepared by the BMD TF in June 2016
- Anticipated Results
  - 1) review of the state-of-the-practice for asphalt mixture design,
  - 2) review the development and state-of-the-practice for performance testing,
  - 3) development of a Recommended Practice for Balanced Mixture Design to implement performance testing in the design of asphalt mixtures, and
  - 4) development of a training and implementation plan and materials to move BMD ahead in State Highway Agencies (SHAs).

NCHRP Problem Statement

I. PROBLEM NUMBER

To be assigned by NCHRP staff.

II. PROBLEM TITLE

Development of a Recommended Practice for Balanced Asphalt Mixture Design

III. RESEARCH PROBLEM STATEMENT

Background

In September 2015, the FHWA Expert Task Group on Asphalt Mixture and Construction formed a Task Force on Balanced Mixture Design (BMD) to move forward changes in the way asphalt mixtures are formulated. The task group has defined BMD as ***"Asphalt mixture design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mixture aging, traffic, climate and location within the pavement structure."*** The objective of BMD is to design asphalt mixtures for performance using a rational approach instead of relying on strictly volumetric guidelines. The Task Force has identified three types of approaches used for a Balanced Mixture Design: A) Performance Testing, B) Superpave with Adjustments Based on Performance Testing and C) Superpave with Adjustments Based on Volumetrics and Performance Testing.

~1 Million tons of HMA placed each day.

- **Critical to address mix design in a more comprehensive manner**

Research Problem Statement – AASHTO Update

- Favorable response during August SOM
- Comments from Oak Metcalfe (TS 2d Chair)…
  - *Technical Section chairs to rank all the proposed research statements that were submitted during the SOM meeting at the beginning of August.*
  - *There are eight total research statements from the SOM with the BMD statement being the only one in the area of asphalt mixtures or binder. (There are several in the area of pavement preservation, including fog seals)*
  - *Rank each RPS on a scale of 1 to 5, with 5 being the highest priority. Our rankings are due to Jack by the 16th of September and there will be a group call to decide the final rankings on September the 23rd.*

Research Problem Statement – Schedule

- Problem Statements Solicited: July 2016
- Problem Statements Due: October 2016
- Evaluations sent to Submitters: Early December 2016
- Ballot sent to SCOR and RAC Members: Mid-December 2016
- Ballot Due: February 2017
- SCOR Meeting: March 2017

FHWA Technical Brief - Draft

- Tech Brief prepared and reviewed by full ETG.
- Revision work currently being handled by the task force.
  - Good document being made better
- Target October for final draft.


TechBrief

The Asphalt Pavement Technology Program is an integrated, national effort to improve the long-term performance and cost effectiveness of asphalt pavements. Managed by the Federal Highway Administration through partnerships with state highway agencies, industry and academia the program's primary goals are to reduce congestion, improve safety, and foster technology innovation. The program was established to

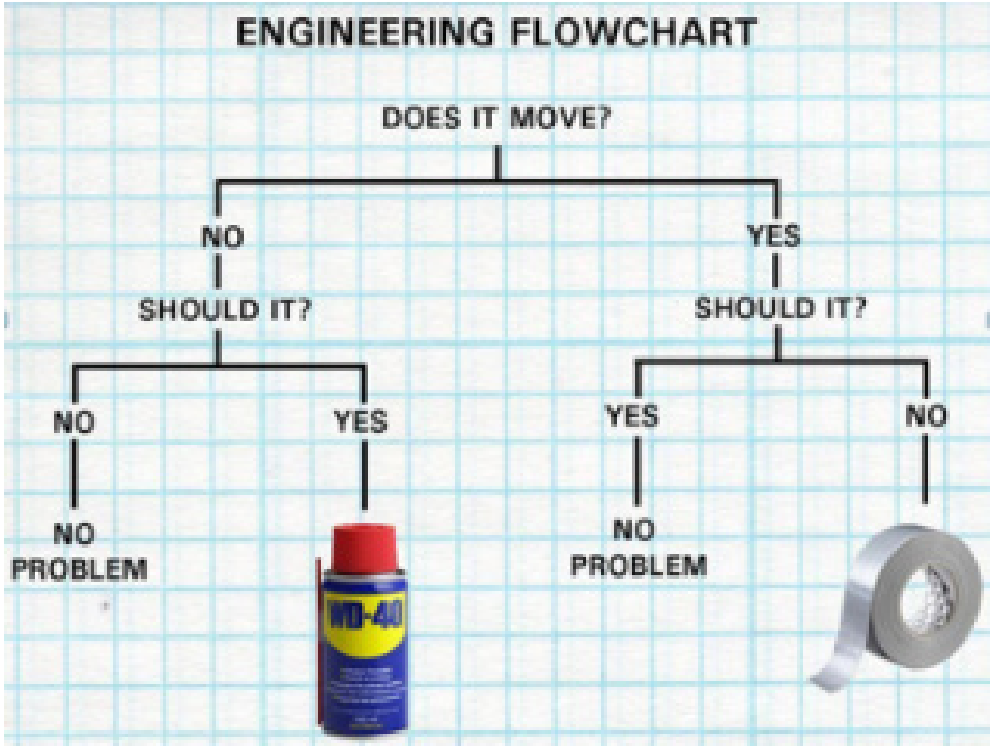
Balanced Mixture Design Approaches for Asphalt Pavement Construction

DRAFT

This *Technical Brief* provides an overview of balanced mixture design (BMD) approaches used by states in asphalt pavement construction. These approaches are still under development and this document will attempt to show its current status and some of the issues that will need to be addressed in the future.

Final Thoughts on Mix Design

- Key Foundational Points to Keep in Mind
  1. **“Use What Works”**
  2. **“Eliminate What Doesn’t”**
  3. **“Be as Simple as Possible, Be Practical, and Be Correct”**



Thoughts and Questions?