Balanced Mix Design Task Force
Update of Activities

Asphalt Mixture Expert Task Group (ETG) Meeting

Salt Lake City, Utah

April 2016

Task Force Development History

- Concern nationally that dense graded mixes are experiencing early age durability related performance issues.
  - Lots of opinions on possible causes
  - Probably a combination of many factors
- Many states have started the process of “performance testing” during mix design and/or production to help ensure mix performance.
  - Process of utilizing performance testing during design has been referred to as a balanced mix design approach.
- Balanced Mix Design Task Force formed at the September 2015 ETG meeting in Oklahoma City

Task Force Membership

Name	Last	First	Affiliation	Category	e-mail
Chris Abadie	Abadie	Chris	Pine Bluff S&G	Industry	abadie3522@icloud.com
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Gerry Huber	Huber	Gerry	Heritage Research	Industry	Gerald.huber@hrglab.com
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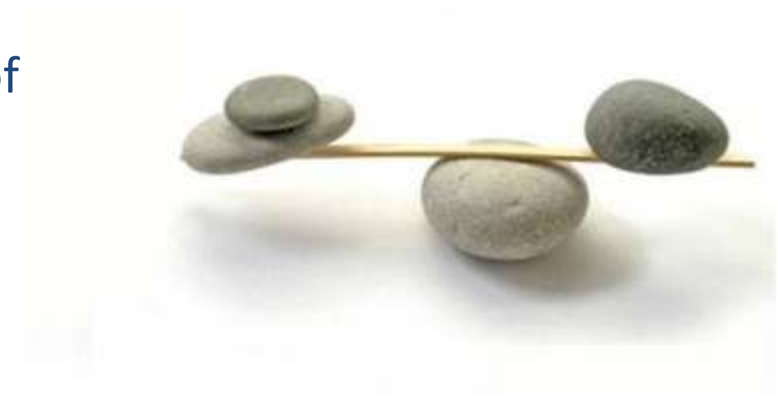
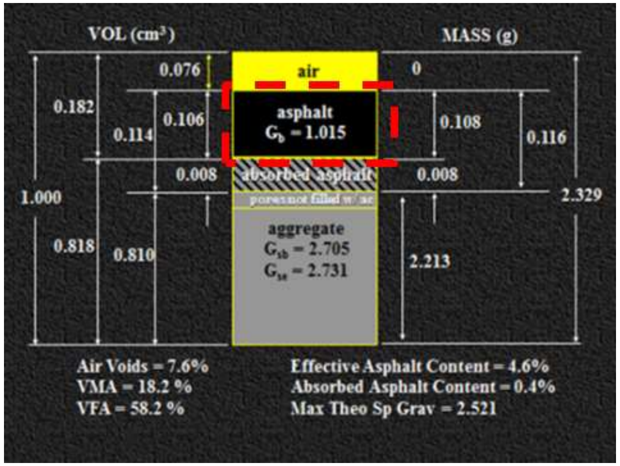
Randy West	West	Randy	NCAT	Research	westran@auburn.edu

Task Force Goals and Focus Areas

- Define Balanced Mix Design
- Determine the current "state of practice" of BMD and performance testing
  - Mix design
  - Field acceptance
- Recommend approaches/concepts for immediate use
- Recommend future needs (potential research) to advance BMD approaches
- Effective dissemination of material

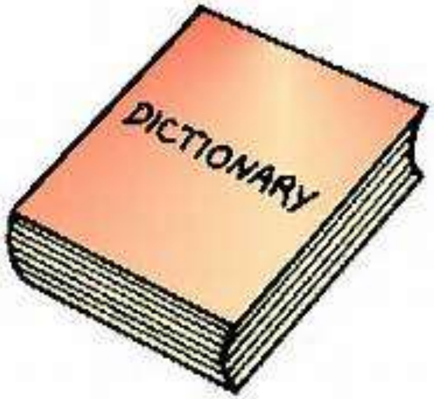




BMD Task Force Work Items

Work Item	Lead(s)
Definition of Balanced Mix Design	All
Laboratory Balanced Mix Design Guidance / Flowcharts	Hall / Mohammad
Field Acceptance Guidance / Protocols	Aschenbrener / Mohammad
Agency State of Practice (Survey of Current BMD Work/Approaches	Chris Abadie / Mohammad

Balanced Mix Design Definition



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."***

- The reasons for using the balanced mix design approach include the following:
  - Evaluating the quality of a mix design relative to anticipated performance using a rational approach
  - Designing mixtures for performance rather than only a volumetric mix design
  - Addressing performance issues that may exist in some areas
    - Cracking from low asphalt binder content
    - Rutting from low fine aggregate angularity, low N-design, low in-place density specifications, etc.
  - Addressing increased binder replacement from use of recycled materials
  - Evaluating mix additive(s) effects which are not directly considered within only a volumetric mix design

Performance Tests

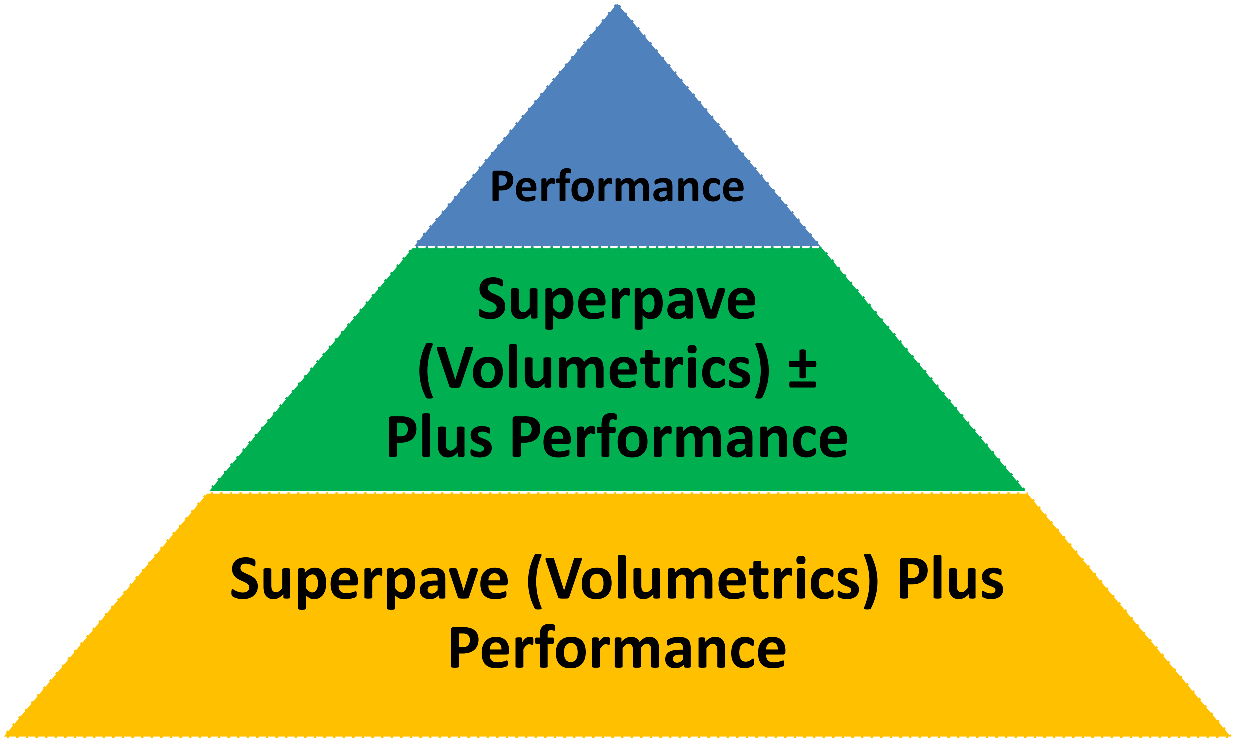
Performance Tests

- Performance Tests
  - All tests related to performance other than those used for volumetric mix design
    - *Examples: Hamburg wheel-track testing, Asphalt Pavement Analyzer, dynamic modulus, beam fatigue, semi-circular bend (SCB), others*
  - *Decision made NOT to distinguish between mechanistic/empirical tests*

Randy West…
"Let's not get bogged down in mechanistic versus empirical semantics. The two most important things are that (1) the test parameter relates to performance, and (2) the test can be implemented for routine use in mix design."

Oldcastle Materials

Hierarchy of Mix Designs



Hierarchy of Mix Designs

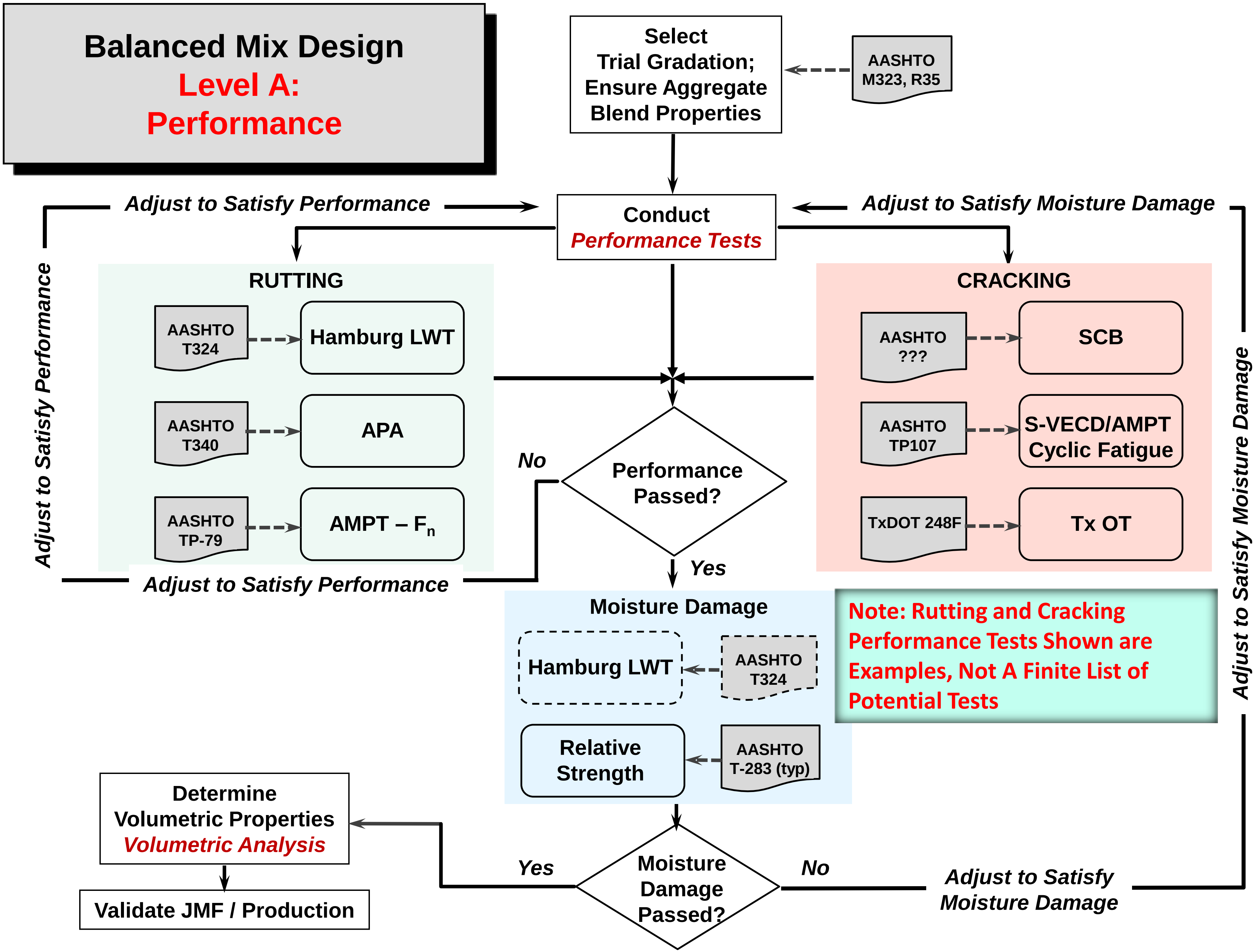
- ***Level A: Mix design to meet performance predictions requirements with measureable performance properties.***
  - ***Performance***

- ***Level B: Mix design to meet requirements of performance tests that address rutting, cracking or other performance criteria as the governing principle of the design with <u>allowable adjustments to volumetric criteria in AASHTO M323.</u>***
  - ***Superpave (Volumetrics) ± Plus Performance***
    - ***± indicates "allowable adjustments"***

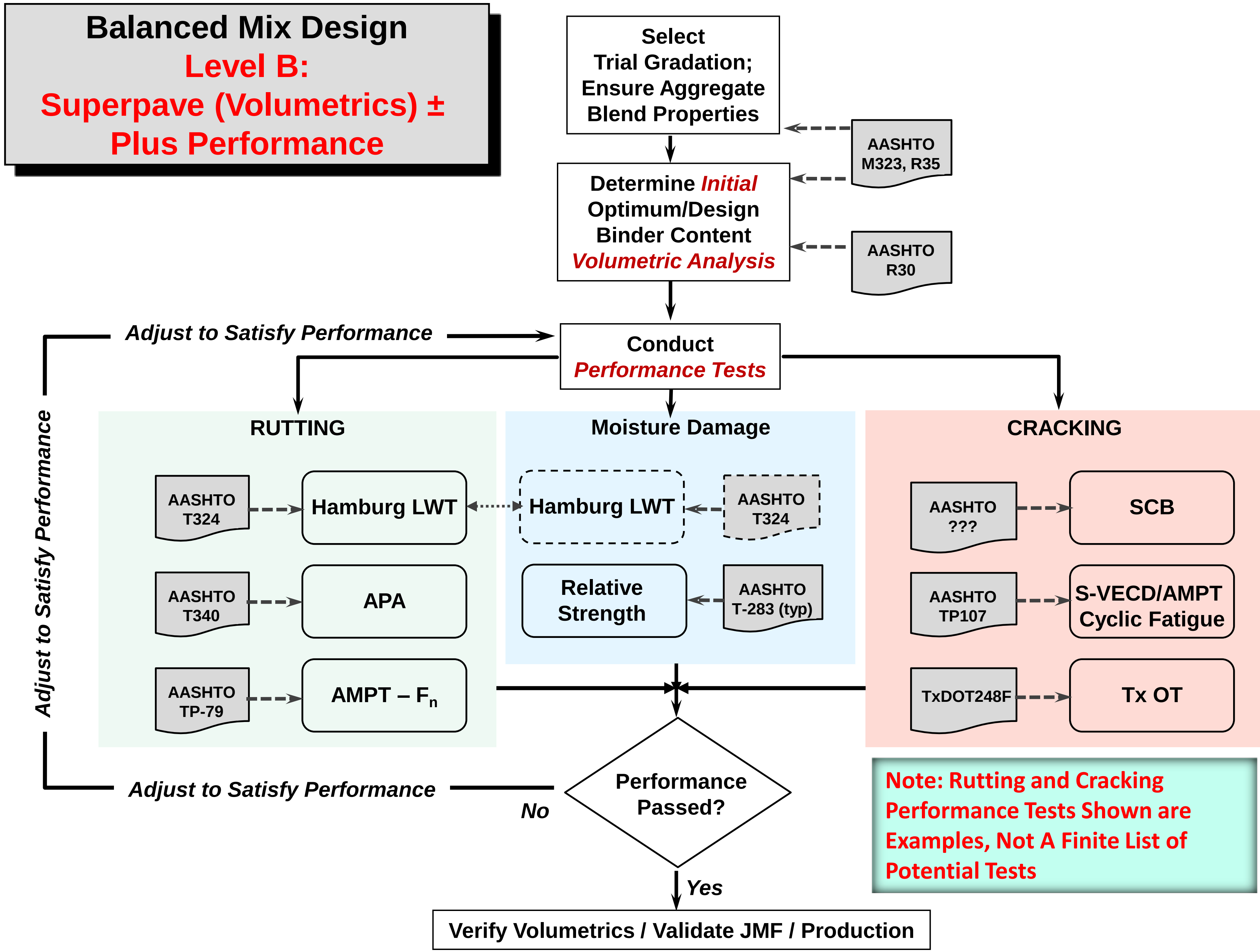
- ***Level C: Mix design according to AASHTO M323 that governs the design, plus the addition of performance tests to address rutting, cracking or other performance criteria.***
  - ***Superpave (Volumetrics) Plus Performance***

Oldcastle Materials

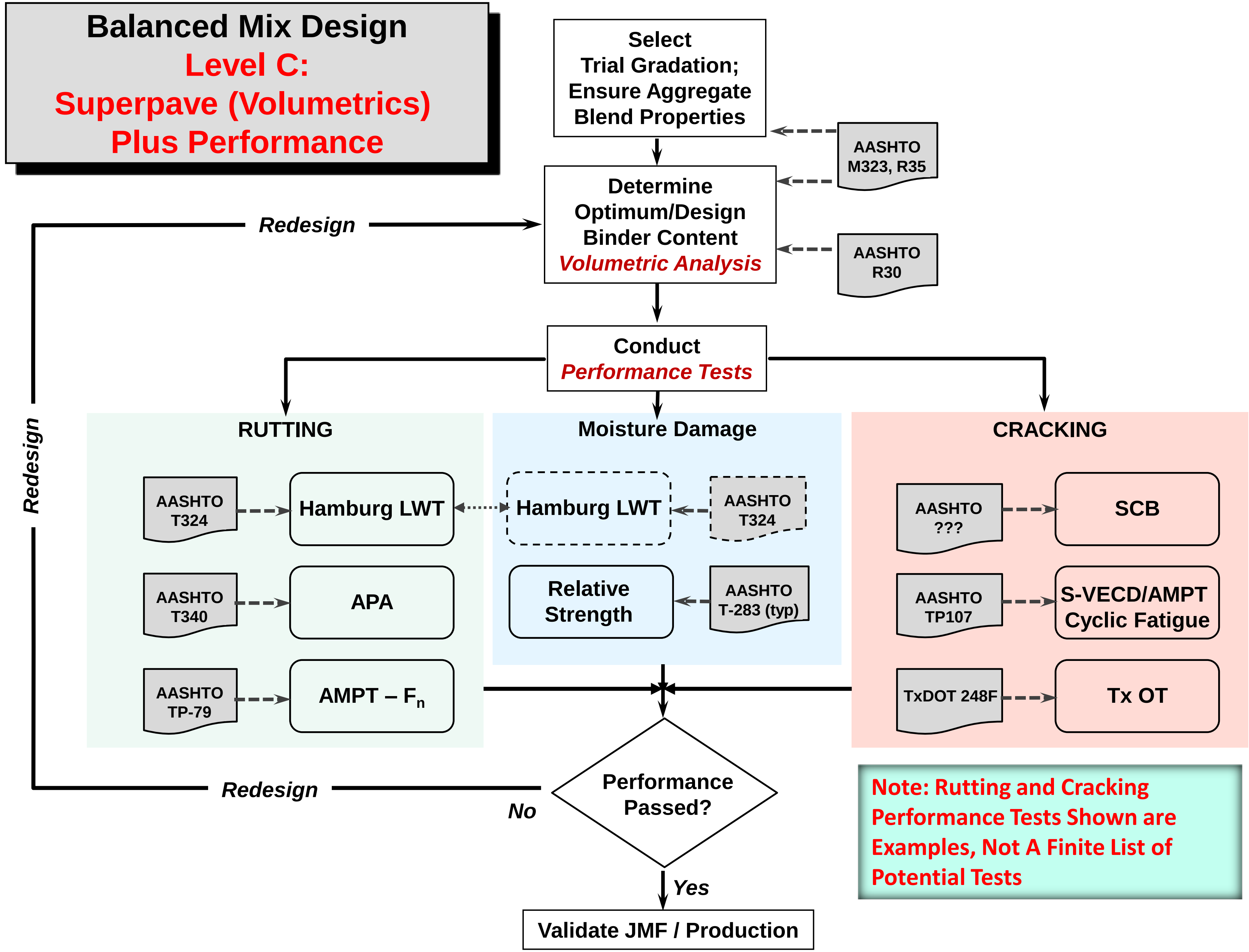
Balanced Mix Design Approach and Development



Balanced Mix Design
Level A:
Performance
Select
Trial Gradation;
Ensure Aggregate
Blend Properties
AASHTO
M323, R35
Adjust to Satisfy Performance
Conduct
Performance Tests
Adjust to Satisfy Moisture Damage
RUTTING
AASHTO
T324
Hamburg LWT
AASHTO
T340
APA
AASHTO
TP-79
AMPT – F_n
CRACKING
AASHTO
???
SCB
AASHTO
TP107
S-VECD/AMPT
Cyclic Fatigue
TxDOT 248F
Tx OT
Adjust to Satisfy Performance
No
Performance
Passed?
Yes
Adjust to Satisfy Performance
Moisture Damage
Hamburg LWT
AASHTO
T324
Relative
Strength
AASHTO
T-283 (typ)
Note: Rutting and Cracking
Performance Tests Shown are
Examples, Not A Finite List of
Potential Tests
Adjust to Satisfy Moisture Damage
Determine
Volumetric Properties
Volumetric Analysis
Validate JMF / Production
Yes
Moisture
Damage
Passed?
No
Adjust to Satisfy
Moisture Damage



Balanced Mix Design
Level B:
Superpave (Volumetrics) ±
Plus Performance
Select
Trial Gradation;
Ensure Aggregate
Blend Properties
AASHTO
M323, R35
Determine Initial
Optimum/Design
Binder Content
Volumetric Analysis
AASHTO
R30
Adjust to Satisfy Performance
Conduct
Performance Tests
RUTTING
Moisture Damage
CRACKING
AASHTO
T324
Hamburg LWT
AASHTO
T340
APA
AASHTO
TP-79
AMPT – F_n
Hamburg LWT
AASHTO
T324
Relative
Strength
AASHTO
T-283 (typ)
AASHTO
???
SCB
AASHTO
TP107
S-VECD/AMPT
Cyclic Fatigue
TxDOT248F
Tx OT
Adjust to Satisfy Performance
Adjust to Satisfy Performance
No
Performance
Passed?
Yes
Verify Volumetrics / Validate JMF / Production
Note: Rutting and Cracking
Performance Tests Shown are
Examples, Not A Finite List of
Potential Tests


Balanced Mix Design
Level C:
Superpave (Volumetrics)
Plus Performance
Select Trial Gradation; Ensure Aggregate Blend Properties
AASHTO M323, R35
Determine Optimum/Design Binder Content
Volumetric Analysis
AASHTO R30
Redesign
Conduct
Performance Tests
RUTTING
AASHTO T324
Hamburg LWT
AASHTO T340
APA
AASHTO TP-79
AMPT – F_n
Moisture Damage
Hamburg LWT
AASHTO T324
Relative Strength
AASHTO T-283 (typ)
CRACKING
AASHTO ???
SCB
AASHTO TP107
S-VECD/AMPT Cyclic Fatigue
TxDOT 248F
Tx OT
Redesign
No
Performance Passed?
Yes
Validate JMF / Production
Note: Rutting and Cracking Performance Tests Shown are Examples, Not A Finite List of Potential Tests

Job Mix Formula (JMF) Development During Balanced Mix Design

JMF

JMF Development

BMD JMF

Balanced Mix Design: Comparison of Volumetric and Balanced Mix Designs
January 19, 2016
Tim Aschenbrener

Case Histories of Setting the Job Mix Formula with a Balanced Mix Design Compared to a Volumetric Mix Design

	State	Aggregate Properties	Aggregate Gradation	Binder Grade	Binder Quantity	Notes on Aging	Observed Mix Design Adjustments
Model A Superpave plus Performance	**Illinois** Building 8 projects this year	Same FAA education	Same	Same	Same Superpave	STA – Hamburg LTA – I-FIT	RAP and RAS quantities Binder source change Construction: silo time, aggregate moisture, plant temperatures
	Texas All specialty mixes for 2-3 years	Same	Same	Same	Same Superpave	STA - Hamburg LTA - Overlay Tester	Asphalt content Binder source change Gradation adjustment for fines (P200) Aggregate source changes
	Wisconsin 4 projects last year	Same	Same	Same	Waive VFA Superpave	STA – Hamburg LTA – DCT and SCB	Binder source and additives Aggregate gradation and fines Rubber
	Louisiana	Same	Same	Same	Same	STA – Hamburg LTA – SCB	
	New Jersey All specialty mixes - 5-10% of statewide tonnage	Same	Same	Open	Same	STA - APA LTA – Beam Fatigue and Overlay Tester	WMA Rejuvenators Polymers Changing effective asphalt content
Model B Superpave ± plus Perf.	**California** 7 Interstate projects to date.	Same - Min. is starting point; usually have to exceed these	Same	Same	Same - May go outside tolerances pending perf. test results Hveem and Superpave	STA – Repeated Shear and Hamburg LTA – Beam fatigue & freq. sweep	Binder source / Aggregate source Binder content Dust : Asphalt ratio Currently developing mix guidance steps (easy and least costly to more difficult and costly) – Report will be available in April.
Model C Performance	**New Jersey** Proposed	Same	Same	Open	Optimum AC determined between lowest and highest asphalt contents from performance tests. A field production tolerance is set at ±0.3% on the optimum.	STA - APA LTA – Beam Fatigue and Overlay Tester	To be determined

Current Practices for Field Acceptance

Field Acceptance Guidelines with BMD

- Document provides background, important considerations, and case studies from states currently utilized BMD approaches.

Field Acceptance

Balanced Mix Design
Field Acceptance Guidelines
January 19, 2016
Tim Aschenbrener

Background:

- After completing a balanced mix design, there is a desire to build a project using this mix design. The purpose of this document is to provide guidance regarding field acceptance of this mix.

Field Acceptance Case Studies

Field Acceptance

Model	State	Mix Design	Acceptance Quality Characteristics	Initial Verification Go / No Go	Ongoing Go / No Go	Information Only	Notes on Aging for Cracking Test
Model 1 Volumetric	California	Volumetric Beam fatigue and frequency sweep Repeated Shear Hamburg	AC/VTM/VMA Field Density			Beam fatigue and frequency sweep Repeated Shear Hamburg	
Model 2 Volumetric plus Performance	Texas	Volumetric Overlay Tester Hamburg	VTM Field Density	Overlay Tester Hamburg	AC/VMA Overlay Tester Hamburg		STA only
	Wisconsin	Volumetric SCB, DC(t) Hamburg	VTM Field Density	DC(t) Hamburg	***DC(t) Hamburg	SCB	Researching 2 types of LTA
	Illinois	Volumetric IL-SCB* Hamburg	AC/VTM/VMA Field Density	IL-SCB* Hamburg	**IL-SCB Hamburg	DC(t)	Researching different types of LTA
Model 3 Performance	New Jersey	Volumetric APA Beam Fatigue Overlay Tester	Field Density	APA Beam Fatigue Overlay Tester	****APA Beam Fatigue Overlay Tester		None
	Louisiana	Volumetric SCB Hamburg	Field Density	SCB Hamburg	****SCB Hamburg AC/Grad.		Researching 2 types of LTA

*IL-SCB is now called the Illinois Flexibility Index Test (I-FIT).

Ongoing Go / No Go – **Frequency at engineer's discretion

***Required frequency- engineer's judgement on addressing test results

****Required frequency – required results

State of Practice

State of Balanced Mix Design Practice

- Survey Responses received from ~27 states.

BMD State Survey

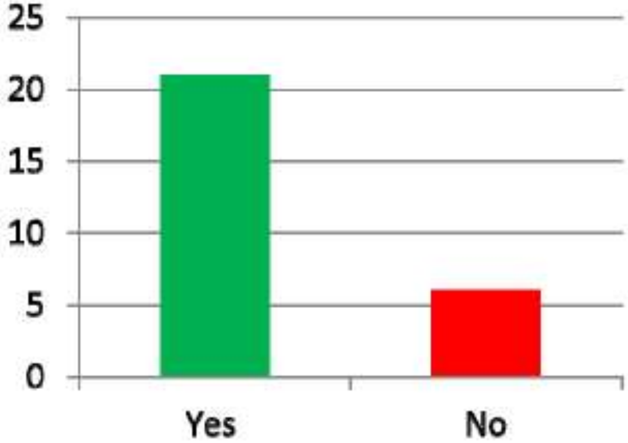
Results of Balance Mix Design Questionnaire

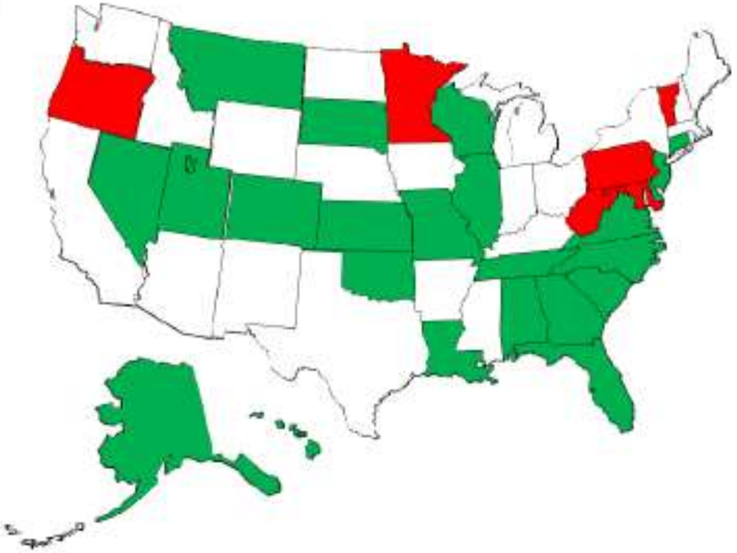
Louay Mohammad
February 11, 2016

State of Balanced Mix Design Practice - Example

Are performance tests used in your current mix design specifications?

- **21** state DOTs reported that they **do**
- **6** states DOTs reported that they **do not**

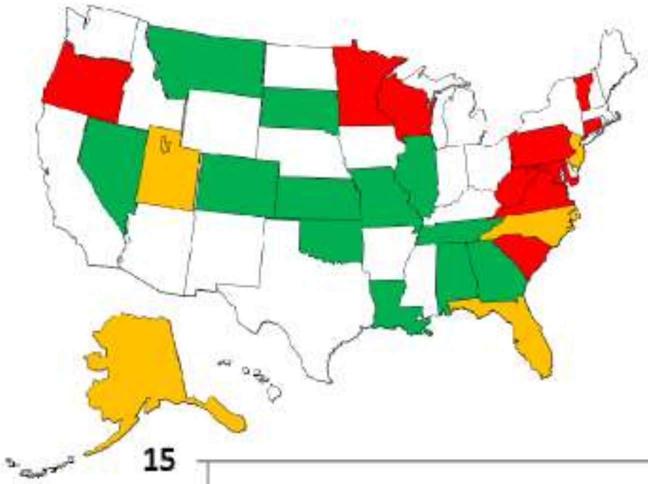


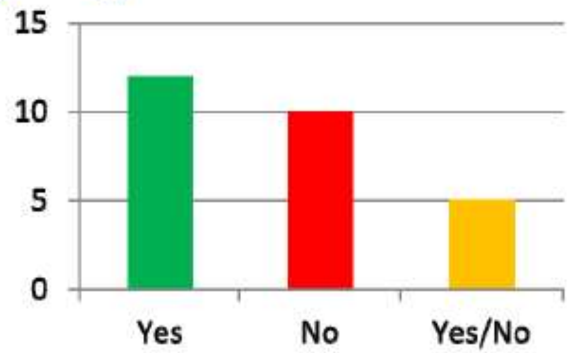


State of Balanced Mix Design Practice - Example

If yes, are the same performance tests used to evaluate mix during production?

- **12** state DOTs reported that they **do** use the same performance tests to evaluate mix during production.
- **10** states reported that they **do not** use the same performance tests to evaluate mix during production.
- **5** states reported that they ***do and do not*** use the same performance tests to evaluate mix during production. They only use it if specific issues arise but not every time.





Observations

- Widespread confusion exists
  - Varying thoughts/ideas…
    - What is balanced mix design?
    - What is performance testing in general?
    - What performance test to use?
    - What performance thresholds to use?
  - Current mix design procedures/ requirements vary considerably among DOTs
    - Highlights the critical need to move forward with a balanced design approach

CONFUSION + CHAOS

Path Forward

Next Steps – Proposed Work Item

1. **Prepare White Paper**
   - **Document current state of practice and task force work**
     - Definition
     - Mix design hierarchy
     - BMD approaches (lab and field acceptance)
     - Agency survey results
     - Pertinent literature on BMD and performance testing
   - **Note:**
     - AFK10 (Frank Fee lead) preparing an E-Circular document
       - "Innovations in Asphalt Mix Design Procedures Workshop", 95th TRB Annual Meeting (2016)
     - Collaborate to ensure consistency, reduce redundancy, and maintain unified message to aid in implementation

Next Steps – Proposed Work Item

2. **Identify issues and deficiencies in current knowledge base and prepare future Research Needs Statement(s) (RNS)**
   - BMD implementation considerations
     - Repeatability / Reproducibility of performance tests
       - Use of test for acceptance/payment
     - Testing time
     - Test simplicity and sensitivity
     - Lab/field correlation
   - Integration of balanced mix design approaches with structural pavement design
     - Consideration items
       - Climate
       - Pavement structure
       - Traffic

BMD – Questions to Be Answered

- Mix Design:
  - How is optimum binder content selected?
- Field Adjustments:
  - What tolerances are allowed?
  - When is a complete mix design re-evaluation required?
  - Can the producer modify the aggregate sources, RAP, RAS, dust to asphalt ratio, etc. in any amount as long as it passes the established test value(s) during production?
- Field Acceptance:
  - What are the quality characteristics and tolerances?
  - Is volumetric testing an adequate surrogate? If not, what?
  - How will field density requirements be established and enforced?

From: Tim Aschenbrener

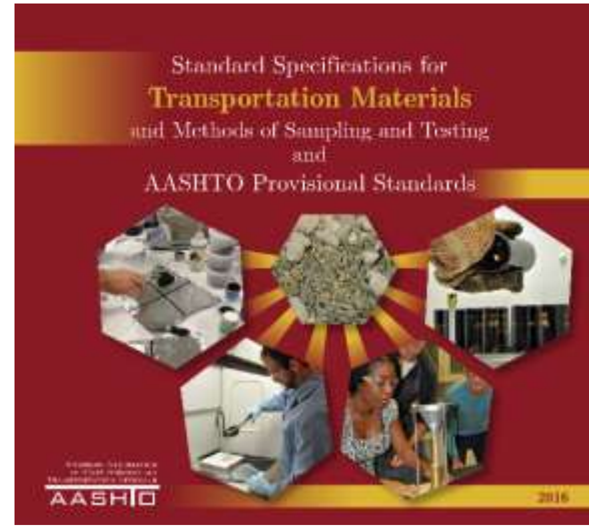
BMD – Considerations for Implementation

- Performance tests…
  - Simplified monotonic loaded single temperature (empirical test)
  - National standard test methods with equipment requirements
  - Aging: long-term vs. short-term
  - Ruggedness testing
  - Precision and bias
  - Sensitivity analysis
  - Acceptance criteria
  - Correlation (Pass / Fail) to actual pavement performance

From: Tim Aschenbrener

Next Steps – Proposed Work Item

3. **Begin development of draft AASHTO standard**
   - Recommended Practice for Balanced Mix Design
     - Present the alternate approaches for BMD
       - User decision based on needs/capabilities
     - Provide links (reference) to the standard test methods for various performance tests



Next Steps – Proposed Work Item

4. **Develop an information clearinghouse webpage for BMD**
   - Similar to www.warmmixasphalt.com
   - Determine responsible parties to host, populate, and maintain site

Thoughts and Questions?