Balanced Mix Design Task Force
Update of Activities

Asphalt Mixture Expert Task Group (ETG) Meeting
Salt Lake City, Utah
April 2016
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
<table>
<thead>
<tr>
<th>Name</th>
<th>Last</th>
<th>First</th>
<th>Affiliation</th>
<th>Category</th>
<th>e-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chris Abadie</td>
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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

<table>
<thead>
<tr>
<th>Work Item</th>
<th>Lead(s)</th>
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<tbody>
<tr>
<td>Definition of Balanced Mix Design</td>
<td>All</td>
</tr>
<tr>
<td>Laboratory Balanced Mix Design Guidance / Flowcharts</td>
<td>Hall / Mohammad</td>
</tr>
<tr>
<td>Field Acceptance Guidance / Protocols</td>
<td>Aschenbrener / Mohammad</td>
</tr>
<tr>
<td>Agency State of Practice (Survey of Current BMD Work/Approaches)</td>
<td>Chris Abadie / Mohammad</td>
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</tbody>
</table>
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.”
Hierarchy of Mix Designs

- **Level A**: Mix design to meet performance predictions requirements with measurable 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 allowable adjustments to volumetric criteria in AASHTO M323.
  - **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**
Balanced Mix Design Approach and Development
Balanced Mix Design
Level A: Performance

Select Trial Gradation; Ensure Aggregate Blend Properties

AASHTO M323, R35

Conduct Performance Tests

RUTTING

AASHTO T324 → Hamburg LWT
AASHTO T340 → APA
AASHTO TP-79 → AMPT – $F_n$

Performance Passed?

CRACKING

AASHTO ??? → SCB
AASHTO TP107 → S-VECD/AMPT Cyclic Fatigue
TxDOT 248F → Tx OT

Note: Rutting and Cracking Performance Tests Shown are Examples, Not A Finite List of Potential Tests

Moisture Damage

Hamburg LWT → AASHTO T324

Relative Strength

AASHTO T-283 (typ)

Moisture Damage Passed?

Yes

Adjust to Satisfy Moisture Damage

No

Adjust to Satisfy Moisture Damage

Determine Volumetric Properties

Volumetric Analysis

Yes

Adjust to Satisfy Moisture Damage

No

Adjust to Satisfy Moisture Damage

Validate JMF / Production
Balanced Mix Design
Level B:
Superpave (Volumetrics) ±
Plus Performance

Select Trial Gradation;
Ensure Aggregate
Blend Properties

Determine Initial
Optimum/Design
Binder Content
Volumetric Analysis

Conduct Performance Tests

RUTTING
Hamburg LWT
AASHTO T324
AASHTO T340
AASHTO TP-79

Moisture Damage
Hamburg LWT
AASHTO T324
Hamburg LWT
Relative Strength
AASHTO T-283 (typ)

CRACKING
SCB
AASHTO ???
S-VECD/AMPT
Cyclic Fatigue
AASHTO TP107
S-VECD/AMPT
Cyclic Fatigue
AASHTO

AASHTO R30

Note: Rutting and Cracking Performance Tests Shown are Examples, Not A Finite List of Potential Tests

Performance Passed?
No
Yes

Adjust to Satisfy Performance
Adjust to Satisfy Performance
Adjust to Satisfy Performance

Verify Volumetrics / Validate JMF / Production
Balanced Mix Design
Level C: Superpave (Volumetrics) Plus Performance

Select Trial Gradation; Ensure Aggregate Blend Properties

Determine Optimum/Design Binder Content
Volumetric Analysis

Conduct Performance Tests

RUTTING

Moisture Damage

CRACKING

Performance Passed?

Yes

Validate JMF / Production

No

Redesign

Redesign

Redesign

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

<table>
<thead>
<tr>
<th>State</th>
<th>Aggregate Properties</th>
<th>Aggregate Gradation</th>
<th>Binder Grade</th>
<th>Binder Quantity</th>
<th>Notes on Aging</th>
<th>Observed Mix Design Adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois Building 8 projects this year</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>STA – Hamburg LTA – I-FIT</td>
<td>RAP and RAS quantities Binder source change Construction: silo time, aggregate moisture, plant temperatures</td>
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<tr>
<td>Texas All specialty mixes for 2-3 years</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>Superpave</td>
<td>STA - Hamborg LTA - Overlay Tester</td>
<td>Asphalt content Binder source change Gradation adjustment for fines (P200) Aggregate source changes</td>
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<tr>
<td>Wisconsin 4 projects last year</td>
<td>Same</td>
<td>Same</td>
<td>Waive VFA Superpave</td>
<td>STA – Hamburg LTA – DCT and SCB</td>
<td>Binder source and additives Aggregate gradation and fines Rubber</td>
<td></td>
</tr>
<tr>
<td>Louisiana</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>STA – Hamborg LTA – SCB</td>
<td></td>
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<tr>
<td>New Jersey All specialty mixes - 5-10% of statewide tonnage</td>
<td>Same</td>
<td>Same</td>
<td>Open</td>
<td>Same</td>
<td>STA - APA LTA - Beam Fatigue and Overlay Tester</td>
<td>WMA Rejuvenators Polymers Changing effective asphalt content</td>
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</table>

- **Model A**: Superpave Plus Performance
- **California**: 7 Interstate projects to date.
  - Starting point; usually have to exceed these
  - May go outside tolerances pending perf. test results
  - Hveem and Superpave
  - STA - Repeated Shear and Hamburg LTA - Beam fatigue & freq. sweep

- **Model B**: Superpave Plus Perf.
  - New Jersey Proposed
  - 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

- **Model C**: Performance
  - 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.

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

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

*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
Survey Responses received from ~27 states.

Results of Balance Mix Design Questionnaire

Louay Mohammad
February 11, 2016
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

![Bar chart and map showing state reporting on performance tests](chart-map)
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
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
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?