Balanced Mix Design (BMD)

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CTEP and APWA

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Bill Pine
Heritage Construction & Materials
What is a “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.”

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

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Agency Approaches:

3 Main Approaches Identified
Why is BMD Needed?
Where are we now?

- **Good to excellent rutting** resistance

- **Less than desirable cracking** resistance

Photos – Buchanan 2017
How Did We Get Here?

• Focused on improving *stability*…
• Relying on *volumetrics alone*…
• **Dry** mixes exist in some (not all) areas…
• Things have *changed*…
  – *Virgin* AC
  – *Increased* use of recycle
  – Lab compactive *effort*
  – *Understanding* the basics – such as *VMA*…
VMA Is All About the Aggregate!

TOTAL Specimen Volume

Voids in the Mineral Aggregate

“Solid” Aggregate Volume
\[ \text{VMA} = \text{Voids} + \text{Effective AC} \]
What is VMA?

Voids in the Mineral Aggregate

- Voids in the total aggregate structure
- Function of aggregate
- Air Voids are function of:
  - Aggregate
  - Effective AC Volume

\[
VMA = 100 - \left\{ \frac{(G_{mb} \ast P_s)}{G_{sb}} \right\}
\]
What is VMA?

Voids in the Mineral Aggregate

- Voids in the total aggregate structure
- Function of aggregate
- Air Voids are function of:
  - Aggregate
  - *Effective* AC Volume

\[ VMA = 100 - \left\{ \frac{(G_{mb} \ast P_s)}{G_{sb}} \right\} \]
Importance of Aggregate $G_{sb}$

- **Accurate VMA**
- Primarily a function of $G_{sb}$ accuracy!
  - Who determines?
  - How is $G_{sb}$ for recycle materials addressed?
  - Design vs. Field?
  - Indicators of accuracy?
Why Is VMA Important?

• Essential Asphalt Mix Properties:
  – Stability
  – Durability

• VMA promotes durability – it is the room between the aggregate particles for AC and Voids
VMA Drives Air Voids
Current Mix Design Specifications

• Largely recipe driven:
  – Aggregates and grading
  – Volumetrics (Va, VMA, VFA, D/A, etc.)
  – Binder grade and/or minimum %
  – RAP and/or RAS
  – WMA
Mix Design Specifications

• This **may** work, but there can be problems:
  – What happens when the recipe fails?
  – Specs have become *convoluted and confounded*
    • Existing specified items compete against each other
    • New requirements get added and nothing gets removed – “Spec Book Creep”
  – Innovation has become stifled with our knowledge outpacing specs
What Are Short-Term Options To Improve Cracking Resistance?

• Increase **EFFECTIVE** AC content:
  – Reduce lab compactive effort?
  – Reduce voids, leave VMA target as is?
  – Increase VMA, leave Voids target as is?
  – Improve accuracy of Gsb (i.e. VMA)?

• Reduce or remove allowance of recycle?

• Increase use of modified AC?

• Increase in-place density requirements?
What Are Long-Term Options To Ensure Cracking Resistance?

• Implement Performance Related Tests:
  – Rutting and Cracking Resistance
  – Design and QC/QA

• Which tests are best?...
Rutting Test Choices…

- Asphalt Mixture Performance Tester (AMPT), formerly known as the Simple Performance Tester
- Hamburg Wheel Tracking Device (HWTD)
- Asphalt Pavement Analyzer (APA), formerly known as the Georgia Loaded-Wheel Tester

http://www.pavementinteractive.org/2014/02/03/performance-tests-for-rutting/
Cracking Test Choices...

- Flexural Bending Beam Fatigue Test
- IDT Fracture Energy Test
- Illinois Flexibility Index Test
- Semi-Circular Bend Test (Louisiana)
- Simplified Viscoelastic Continuum Damage Test
- Texas Overlay Test
- IDT Energy Ratio
- Disc-Shaped Compact Tension Test
- IDT Creep Compliance and Strength Test
- Low Temperature Semi-Circular Bend Test
- Thermal Stress Restrained Specimen Test
- Cantabro Test

- AASHTO T 321-14 / ASTM D7460-10
- N/A
- IL TP 405/AASHTO TP 124-16
- LADOTD TR 330-14/ASTM D8044-16
- AASHTO TP 107-14
- NJDOT B-10 / Tex-248-F
- N/A
- ASTM D7313-13
- AASHTO T 322-07
- AASHTO TP 105-13
- BS EN 12697-46:2012
- AASHTO TP 108-14

Mixture Cracking Tests from DRAFT FHWA Tech Brief
FHWA Technical Brief – Draft

- Technical Brief being developed to provide a current summary of the BMD TF efforts.
- Publication very soon!

**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.

**Balanced Mixture Design Approaches for Asphalt Pavement Construction**

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

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Upcoming Research:
NCHRP Project 20-07/Task 406

- Development of a Framework for Balanced Asphalt Mixture Design
- 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.

NCHRP Project 20-07/Task 406, FY 2017
Development of a Framework for Balanced Asphalt Mixture Design
Funds Available: $100,000
Contract Time: 12 months (includes 3 months for NCHRP review and for contractor revision of the final report)
Staff Responsibility: Edward Harrigan, 540-454-2149 (email: eharriga@nas.edu)
Authorization to Begin Work: 04/01/2017 (estimated)
Proposal Due Date: 01/26/2017

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Questions To Ask When Choosing A Performance Test…

- Does the test *clearly* relate to field performance?
- How *easy* is it to perform?
- How much *time* does it take?
- What does the equipment *cost*?
- Recommended specs, mix/specimen aging and parameters *relative to* our mixes/area?
  - Are the acceptance parameters the same for all mix types, sizes and uses?
Choosing A Performance Related Test…

• Which tests answer these questions best?
  – If your agency already has a perf test, is there clear evidence that it relates to performance?
    • Are there areas for improvement?
    • Do the specs need adjusted?
  – If your agency doesn’t have a perf test, what are surrounding agencies using or planning to use?
Implementation Considerations
Agency and Industry

- Cost and time to implement?
  - Lab personnel training needed?
    - Conduct round robin?
    - Require accreditation?

- Specification development?
  - Recommended aging protocol?
    - Short-term / long-term?
    - Mix design / plant produced mix?

- Pilot projects?
Implementation Considerations

Agency

- What current specification requirements can be *relaxed or removed* completely?
  - Binder grade bumping?
  - Allowance of AC modifiers PROCESSES?
  - Aggregate blend requirements?
  - QA tests such as VMA, Voids, AC content, blend gradation?
  - Others?
Implementation Considerations

Industry

• Back to the *basics*:
  – Accuracy of typical measurements like aggregate Gsb, Gmb, Gmm, AC content?
  – Tracking of product variability and the need to minimize?
    • Virgin AC?
    • Virgin aggregates?
    • Recycled products?
Implementation Considerations

Industry

• Back to the *basics* (continued):
  – Production and laydown variability?
    • Silo time?
    • Mix production temperature?
    • Uniformity of products being fed into the plant and the way we go about introducing them?

• *Investigate* which mix properties have the most influence on performance test results
Implementation Considerations

Industry

• Will it open the door for innovation?
  – *Optimum* VMA?
  – *Optimum* Voids?
  – Use of rejuvenators?
  – WMA?
  – Impact of field density achieved?
  – Etc.
Closing Thoughts

• Current performance concerns?
  – Identify spec short-comings, then
  – Enact some short-term solutions, but do it *jointly* (i.e. Agency and Industry)

• Next step to improve performance?
  – Investigate available performance tests
  – Address the various questions
    • Agencies, Academia and Industry **must** work together – Make the “best” choices and get started!
Questions?

Bill Pine
Heritage Construction & Materials
Cell: (217) 840-4173
E-mail: billp@thgrp.com

Thank You!