Overview

Quick overview of BMD
Completed and ongoing NCAT research related to BMD
Questions to answer

What is BMD?

- BMD Task Force defined BMD as “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.”
- Long story, short
  - A design methodology which uses a rutting test and a cracking test to balance mixture performance

Why is BMD Needed?

- Concerns with the volumetric mix design system
  - Dry mixes with durability/cracking issues
  - Issues with accurately determining aggregate specific gravity
  - Volumetrics not adequately sensitive to mix variables (WMA additives, polymers, recycling agents, fibers, etc.)
- Move to performance based testing
  - Design for performance instead of just to “the specifications”
  - Understand design factors that drive performance

Differing Approaches by State

- Experience and preference on performance tests
  - Texas overlay (OT)
  - Illinois Flexibility Index (I-FIT)
- Pavement distress considerations
  - Top-down cracking
  - Thermal cracking
  - Reflective cracking
- Intended mix applications
  - High recycled mixes
  - Thin overlay mixes

Expected Impacts of BMD

- Higher asphalt contents
- Increased use of additives/modifiers
- Greater investment in lab equipment
- More time to complete mix design
- Greater freedom to innovate
- Improved pavement performance
- Extended pavement service life
Ongoing NCAT Research
- NCHRP 20-07 Task 406 (Recently completed)
- Development of a Framework for BMD
- WHRP 0092-16-06 (Recently completed)
- Regressing Air Voids for Balanced HMA Mix Design
- 2015 NCAT Southern Cracking Group Experiment
- 2016 MnRoad Northern Cracking Group Experiment
- 2018 Test Track Research Cycle
- BMD Production Testing Study
- NCAT Performance Testing Round Robin

NCHRP 20-07 Task 406
- Overview of Asphalt Mixture Performance Tests
  - Procedure
  - Results
  - Equipment and Approx. Cost
  - Specimen Fabrication
  - Testing Time
  - Complexity of Analysis
  - Variability
  - Field Validation
  - Overall Practicality

Identifying Knowledge Gaps
1. Develop draft test method and prototype equipment
2. Evaluate sensitivity to materials and relationship to other lab properties
3. Establish preliminary field performance relationship
4. Conduct ruggedness experiment
5. Develop commercial equipment specification and pooled fund purchasing
6. Conduct round-robin testing
7. Robust validation to set specification criteria
8. Training and certification
9. Implement into engineering practice

WHRP Regressed Air Voids Study
- Regressed Air Voids
  - Design mix to 4.0% air voids and meet volumetric requirements
  - Add virgin binder to reach design air voids of 3.5% or 3.0%

WHRP Regressed Air Voids Study
- Evaluate impact of air void regression on 6 WI mix designs
  - 4.0, 3.5, 3.0% air voids
  - Hamburg, I-FIT, DCT
- Air void regression from 4.0 to 3.0% design air voids resulted in 0.3% to 0.4% higher design AC contents
WHRP Regressed Air Voids Study
- For the mixtures evaluated, air void regression generally...
- Did not compromise rutting resistance in the Hamburg
- Improved intermediate temperature cracking resistance using the I-FIT
- Did not statistically improve low temperature cracking resistance in the DCT
- Regressed air voids concept can be used as a bridge to BMD Implementation

Southern Cracking Group (CG)
- 7 Test Sections
- 7 Unique Surface Mixtures
- Top-Down, Load-Related Cracking
- Compare Field Cracking Performance to Laboratory Cracking Test Results
- Constructed in 2015

Southern Cracking Group (CG) Development of Critical Aging Protocol (CA)
- Target 70,000 Cumulative Degree Days
- 3-5 years of field aging in Alabama
- 8 hrs. at 135°C on loose mix for Test Track Materials

Testing Plan
- 2 aging conditions (STOA/RH and Critically Aged)
- 2 production methods (LMLC and PMLC)
- 6 cracking tests (I-FIT, SCB-Jc, ER, OT-TX, OT-NCAT, IDEAL-CT)
- 7 unique surface mixes
- ≈ 168 sets of specimens

MnROAD/NCAT Cracking Group Experiments
NCAT Test Track
- Top-Down Cracking
MnROAD
- Low-Temperature Cracking

Southern Cracking Group (CG) Preliminary results presented at 2018 Test Track Conference
Draft Report (18-04D) on NCAT website
For these mixes, good correlation between 4 of the 6 cracking tests
- I-FIT, IDEAL-CT, OT-TX, OT-NCAT
- Generally identified first mix to crack and have the mixes with no cracking among the top performers after one cycle of traffic
- Will use final field cracking results to develop lab to field correlations

SEAU PG Annual Meeting Raleigh, North Carolina November 13-15, 2018

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<th>Section</th>
<th>Description</th>
<th>Rutting (mm)</th>
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<th>Δ MTD (mm)</th>
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* = Low Severity Hairline Cracking
Performance after 1 research cycle (~10 million ESALs)
Trafficking to continue in 2018 Test Track Research Cycle
Northern Cracking Group (CG)
- Constructed on MnROAD Mainline during Summer and Fall of 2016
- Establish lab to field correlations between pavement performance and laboratory cracking tests
- 8 Test Sections
  - Same Pavement Structure
  - Asphalt mixes with varying degrees of cracking potential
  - Focused on thermal cracking but will quantify other types of cracking as well

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Northern Cracking Group (CG)
- Laboratory Testing Plan
  - DCT, I-FIT, IDEAL-CT, OT, Low Temperature IDT, Beam Fatigue
  - Critically Aged Testing ongoing
    - 6 hours at 135°C on loose mix
    - Simulate 4 to 5 years of aging in Minnesota
  - Traffic ongoing but no thermal cracking has occurred yet

2018 NCAT Test Track – BMD Sections
- Two surface mixes on Test Track
  - Control: 30% RAP, PG 64-22
  - Experimental: 45% RAP, PG 64-22 with Anova
- Both designed as BMD mixes to meet VDOT Performance Requirements
  - APA, Cantabro, IDEAL-CT

Experiment Objectives
- Implementation of performance testing and criteria for BMD
- Performance comparison for BMD versus volumetric mixes
- Implementation of BMD procedures in asphalt mixes containing rejuvenators and high RAP levels

2018 Test Track – Cargill BMD
2018 Test Track – ODOT BMD
- Hamburg and I-FIT used during the design process
- Section N9
  - 1.5” Mill and Inlay
  - Volumetric Design with Performance Verification
- Section S1
  - 5.5” mill and inlay (2 lifts)
  - Performance Modified Volumetric Design
  - Select 3 initial AC contents
  - Determine Opt AC based on I-FIT and Hamburg
  - Verify Volumetric Properties

2018 Test Track – TxDOT BMD
- 2.5 in. mill and inlay
- S10 BMD, S11 volumetric control
- Designed by University of Texas at El Paso (UTEP)
  - TxDOT 12.5mm SP-C surface mix
  - PG 70-22 binder
  - 20 percent RAP binder replacement ratio
  - Volumetric design with performance verification

2018 Test Track – TxDOT BMD
- HWTT for rutting and moisture resistance
  - Max. rut depth of 12.5 mm at 50°C
- Overlay Test (OT) for cracking resistance
  - Min. critical fracture energy (Gc) of 1.0 in.-lb/in.²
  - Max. crack progression rate (β) of 0.45 (surface)

BMD Production Testing Study
- 5 mixtures produced and placed on the 2018 NCAT Test Track
- Produce hot-compacted (no reheating) specimens for each of these five mixes for commonly used rutting and cracking tests:
  - Hamburg, High Temp IDT, I-FIT, OT, IDEAL-CT
- When a mix is tested in different ways, how different are the results?

Why is this important?
- If tests are used for pay, how are results impacted by mix type and handling conditions?
  - If a contractor designs a mix to a FI value of 8, would he still get that value when the mix is produced in the field?
  - If a contractor and agency are comparing results for QA, will they get different values if one is using re-heated plant mix and the other is making hot compacted specimens?
  - Is it feasible to use more rapid surrogate tests during production?

NCAT Performance Testing Round Robin
- Sampled 200 buckets of one mixture during Test Track construction
- 50 labs have agreed to participate
- Labs selected test(s) they wanted to run
  - HB, I-FIT, APA, IDEAL-CT, OT, DCT
- Better grasp on between lab results for multiple performance tests
- Mix and instructions shipping soon
Questions to Answer

- Ruggedness experiments to refine performance tests
- Precision statements for performance tests
- How to address performance testing during production?
- QC/QA?
- Training materials and courses
- What cracking test(s) best predict field performance?
- How should mixture aging be addressed during mix design and production?

Thanks!