Balanced Mix Design Oklahoma Perspective

67th Annual KU Asphalt Paving Conference

December 7, 2023

OKLAHOMA Transportation

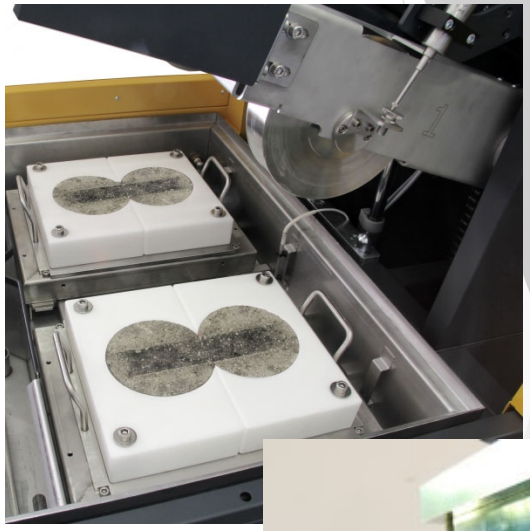
OKLAHOMA ASPHALT PAVEMENT ASSOCIATION

Oklahoma BMD Objectives

- Reduce the cracking potential of asphalt mixes
- Extend the life of pavements
- Sustainable and cost-effective mixes
- Simplify the mix design process
- Allow innovation and the use of new technologies

Performance Tests

- Hamburg Wheel Tracking Test (HWTT)
  - ODOT currently uses it for rutting potential evaluation of all new mixes
  - Required for mix design acceptance
  - Will obtain new equipment and explore SIP for moisture susceptibility evaluation
  - Current max rut depth of 12.5mm at 10k, 15k, or 20k passes
- Ideal Cracking Test (Ideal-CT)
  - ODOT current cracking test for initial implementation phases
  - Gathering testing data and evaluating reliability and variability between ODOT and Producers
  - Previous Criteria CT-Index = 80 All mixes
  - Current Criteria CT-Index = 100 Surface / 60 Intermediate



Implementation Plan Overview

Phase 1
BMD evaluation

- Literature Review and Equipment

- Test Selection

- Shadow Projects - 2018

Phase 2
Proof of Concept

- Develop Initial Special Provision

- Identify Challenges

- Pilot Projects - 2022

Phase 3
Long-Term Eval.

- Benchmarking and Field Study

- Evaluate Aging Protocols

- Pilot Projects - 2023

Phase 4
Implementation

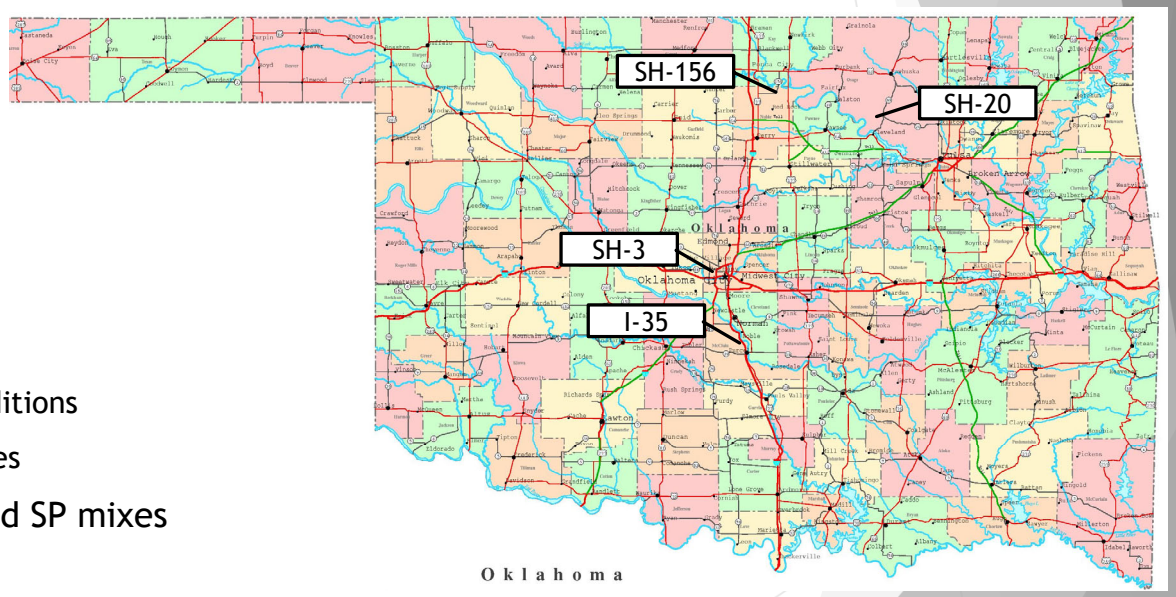
- BMD Partnership

- Evaluate Field QC/QA

- Implementation Projects - 2024

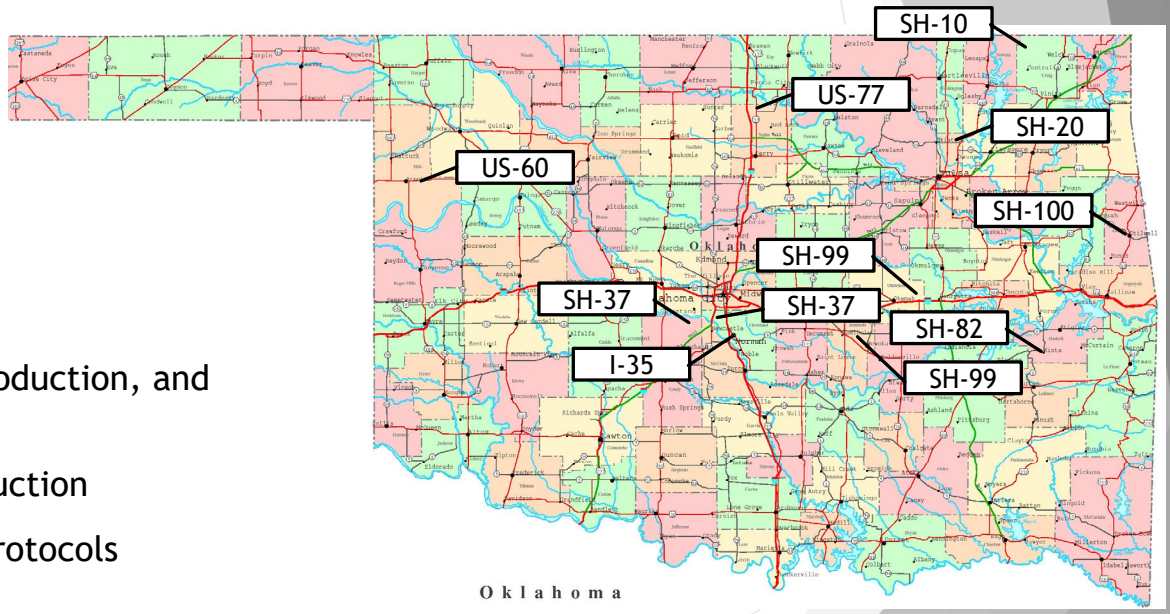
Phase 1 – Understanding BMD

- Familiarize with the concept
- Evaluated I-Fit and Ideal-CT tests
- Assess tests variability
- 2018 Shadow Projects
  - 4 Projects were selected
    - Different Distresses and Traffic Conditions
    - 1 SP control and 1 or more BMD mixes
  - Gather cracking test data of BMD and SP mixes
  - No Volumetric Changes to Spec
  - RAP allowed on the surface (up to 15%)

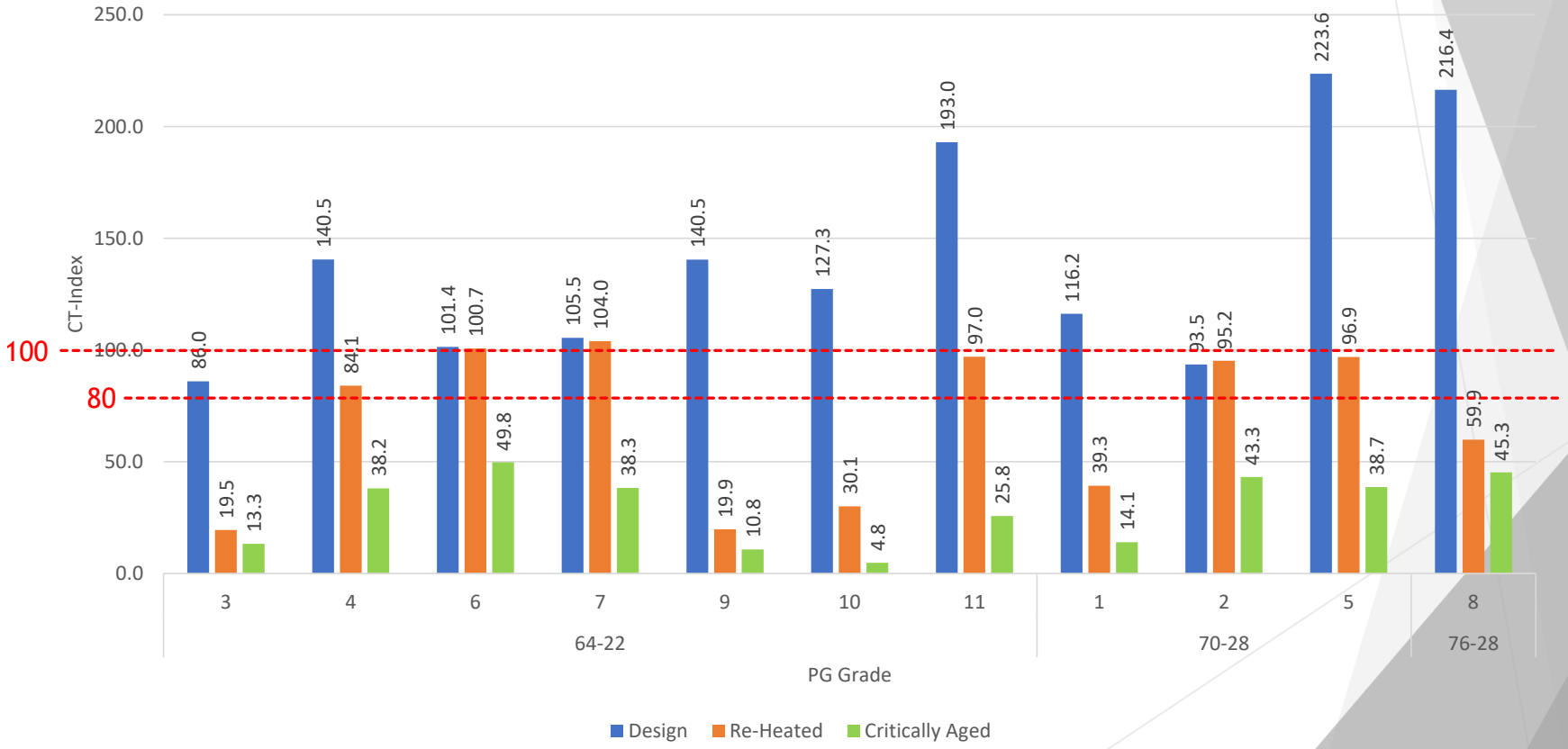


Phase 2 – Proof of Concept

- 11 Projects across the state
  - 19.0 and 12.5 mm NMAS mixes
  - HMA and WMA mixes
  - No Superpave control mixes
- Expected Outcomes
  - Use the new Special Provision
  - Identify challenges during design, production, and construction
  - Difference between design and production
  - Validate short and long-term aging protocols
  - Assess RAP binder blending
  - All 11 projects and testing completed by Dec 2022



2022 Pilot Projects Results – By PG Grade



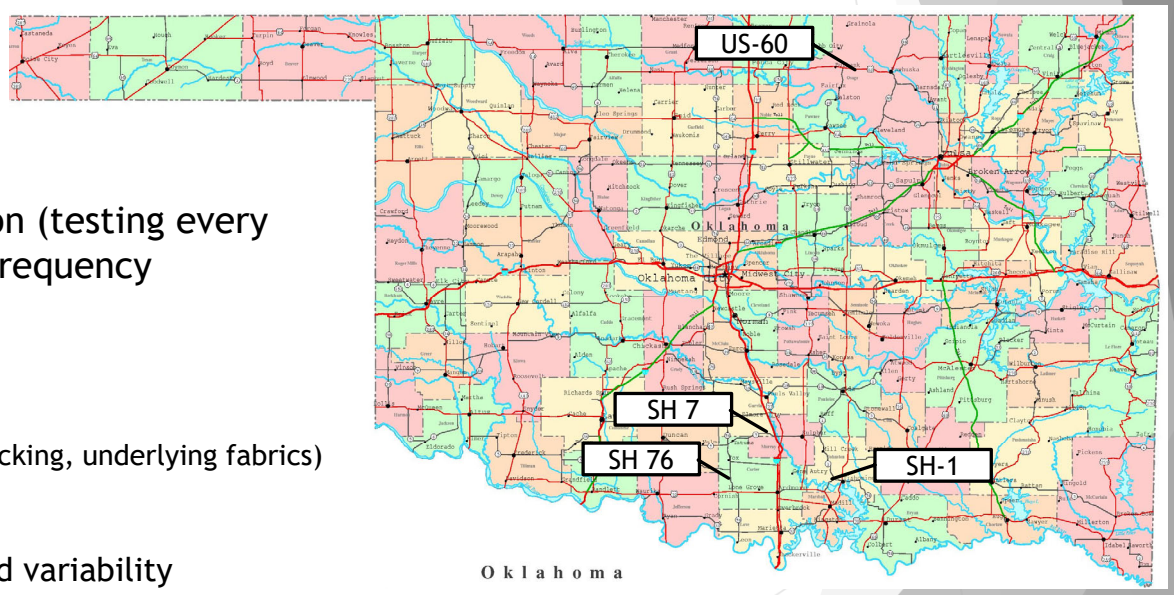
Phase 2 Pilot Projects - Lessons Learned

- Lessons Learned
  - High variability between labs
    - Round Robin to be performed to address variability
  - Design and production CT-Index discrepancies
  - Some producers have consistent design and production values
  - Expected decrease between Re-Heated and Critically Aged
  - Understanding PG grading from extraction
  - Overall, no issues during the construction

- Changes to Special Provision
  - Short Term Aging from 2 to 4 hours during design
  - Max RAP content from 40% to 30% with a softer binder for intermediate and base mixes
  - Determine RAP AC content by extraction only
  - Change the pay factor formula to accommodate the new target range

Phase 3 – Variability and Long-Term Evaluation

- Designed considering PMS limitations
  - Control and BMD in the same direction
- Assess tests variability during production (testing every 1,000 tons) to determine field testing frequency
- 2023 Pilot Projects
  - 4 Projects were selected
    - Different Existing Conditions (severe cracking, underlying fabrics)
    - 1 SP control and 1 BMD mix
  - Evaluate RAP management practices and variability
  - Use of updated special provision, new criteria, and aging protocol
  - RAP allowed on the surface (up to 25%) with a softer binder



Phase 3 – Benchmarking and Field Verification

- Production Benchmarking – Task Order
  - Up to 50 Mixes to be sampled
  - Ideal-CT testing and HWTT (full BMD profile)
- Design Benchmarking – In-House
  - 2 additional Hamburg specimens for ALL MIXES for approval
  - Ideal CT during design additional to the current HWTT testing
- Field Verification – Task Order
  - Use 3D-Scan to survey the current conditions of 2018 projects
  - Assess: cracking, rutting, ride, comparison with conventional
  - Scan 2022 and 2023 pilot projects

Phase 3 and 4 – Team Effort

- BMD Task Force ODOT-Industry
  - ODOT – Industry (OAPA)
  - Ongoing since 2018
  - Discuss industry concerns
  - Hear industry input, ideas
  - Technical exchange
    - Discuss challenges, lessons learned,
  - Open forum for discussion

- BMD ODOT-Consultant Partnership
  - ODOT - Consultant
  - Centralized coordination and workforce support
  - Fine-tune BMD special provision
  - Set goals for 2024 implementation projects
  - Assist with research management (Local universities and NCAT test track)
  - Training to residencies, producers, designers
  - Assist with additional testing, round robins

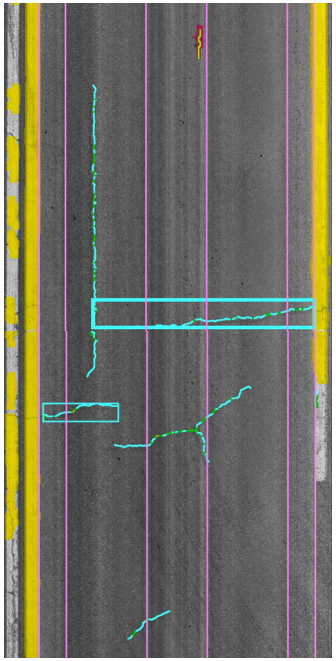



Phase 4 – 2024 Implementation Projects

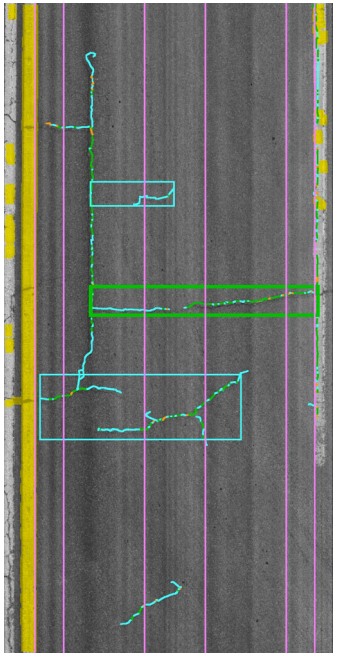
- Use of Special Provisions developed by the Partnership and Task Force
- Project selection based on determined criteria
- Will include a training component (workshops) for residencies and field personnel
- Considering long-term monitoring
- Include a Superpave control mix for performance comparison
- 1 Project per district (at least 8 projects)
- 1 Load frame per residency
  - Determine QC/QA procedures and frequency
- Evaluate the adoption of Approach D (Performance Design)

Phase 4 – Long-Term Monitoring

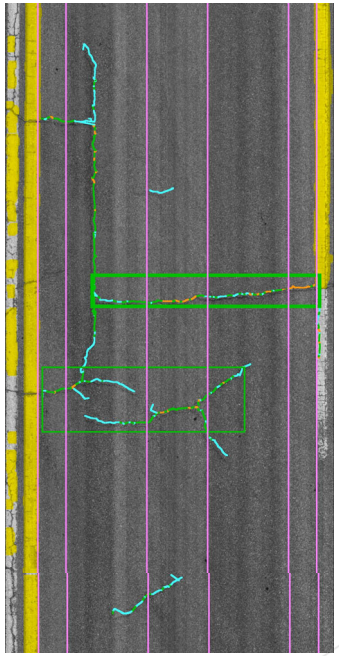
- ODOT Pavement Management System Yearly Conditions Survey



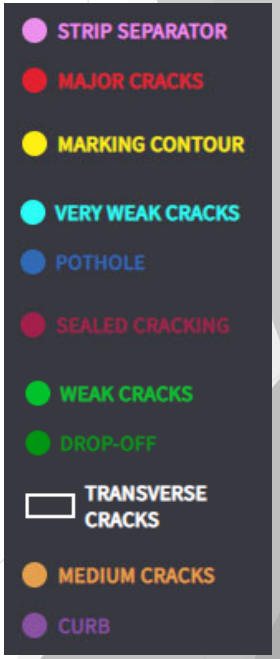
2020



2021



2022

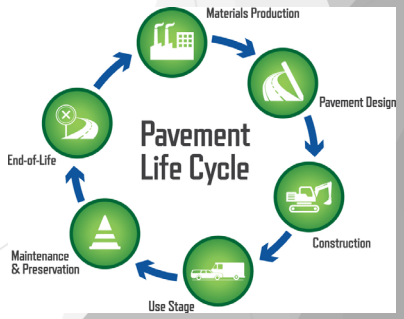


KEY

Future of BMD

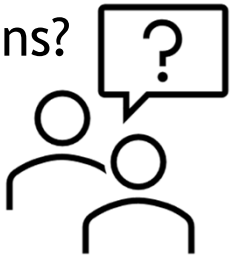
- Initial implementation for the design phase
  - Expected end of 2024
  - Benchmarking and field verification projects completed
  - Determine final criteria for cracking test
  - Assess the potential use of Approach D
- Initial implementation for QC/QA use of BMD tests
  - Expected outcome of partnership by 2025
  - Determine field tests for cracking and rutting tests
  - Determine criteria and testing frequency
- Environmental impacts and new technology
  - FHWA Climate Challenge, LCA framework
  - WMA technology with BMD (ongoing), Additives, Rubber

CLIMATE CHALLENGE



Thank you

Questions?



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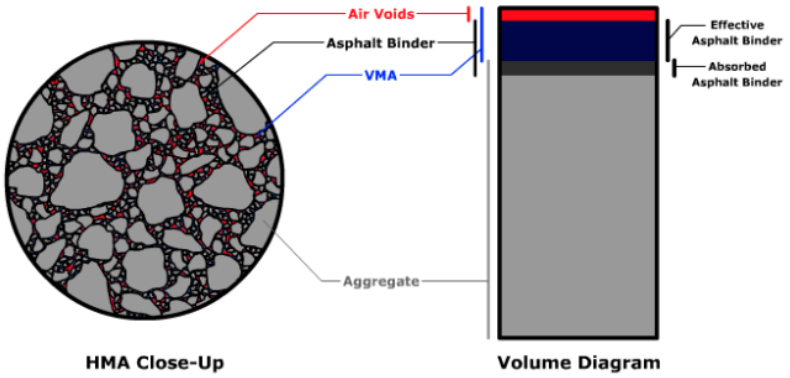
Background

- Superpave - Current Asphalt Mix Design
  - Developed from 1987 to 1993
  - Original vision of Superpave included Level 1 based on volumetrics and materials properties, and Levels 2 and 3 based on performance but never implemented
  - Performance tests at the time were not practical and expensive
  - The focus was rutting resistance
  - Primary form of distress now is cracking

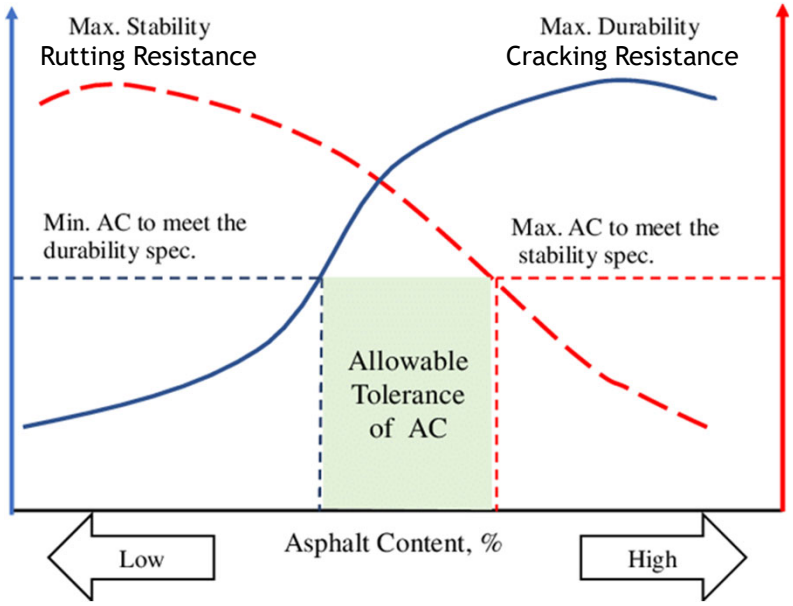


Rutting

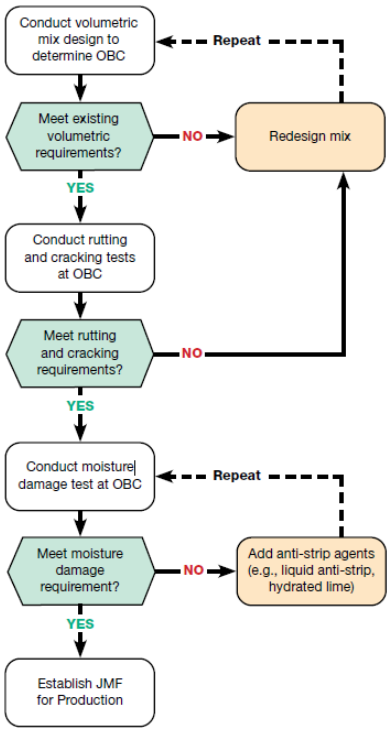
Cracking

Balanced Mix Design (BMD) Concept

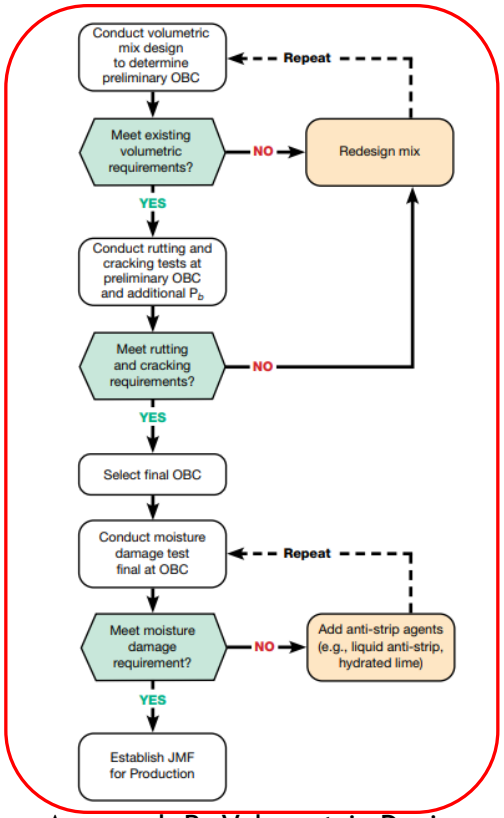
- BMD Definition (FHWA – 2015)
  - Asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate, and location within the pavement structure.
- BMD Goal
  - Balance rutting and cracking potential for optimum performance



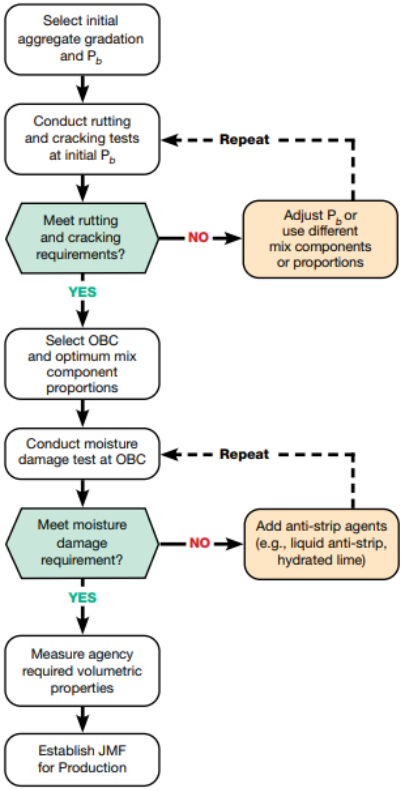
BMD Approaches



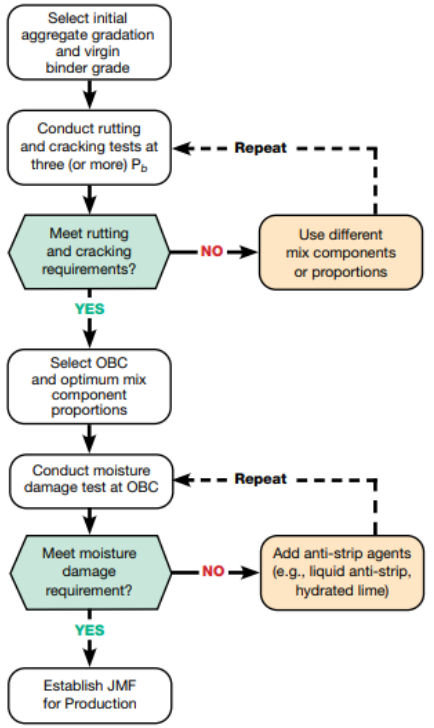
Approach A: Volumetric Design with Performance Verification



Approach B: Volumetric Design with Performance Optimization

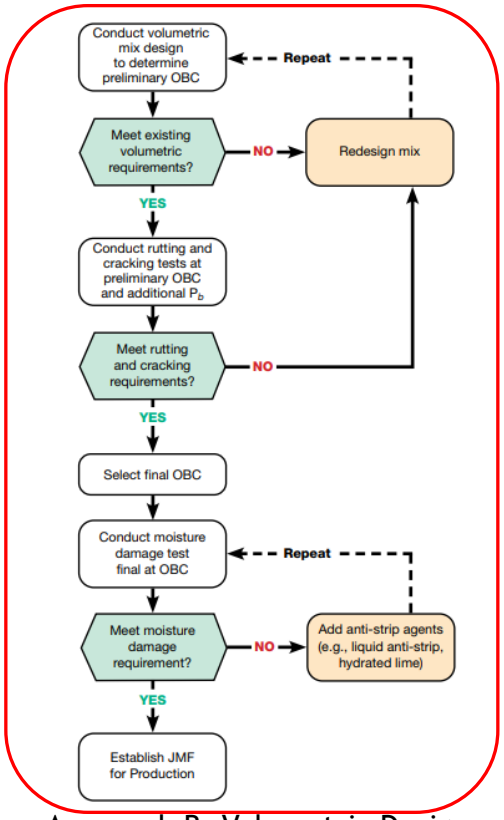


Approach C: Performance-Modified Volumetric Design

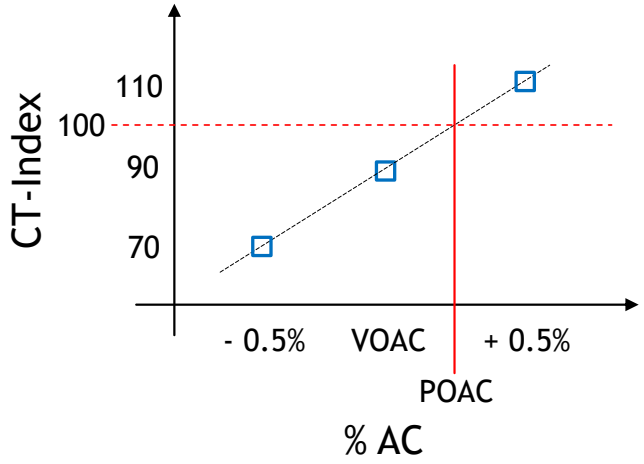


Approach D: Performance Design

BMD Approaches

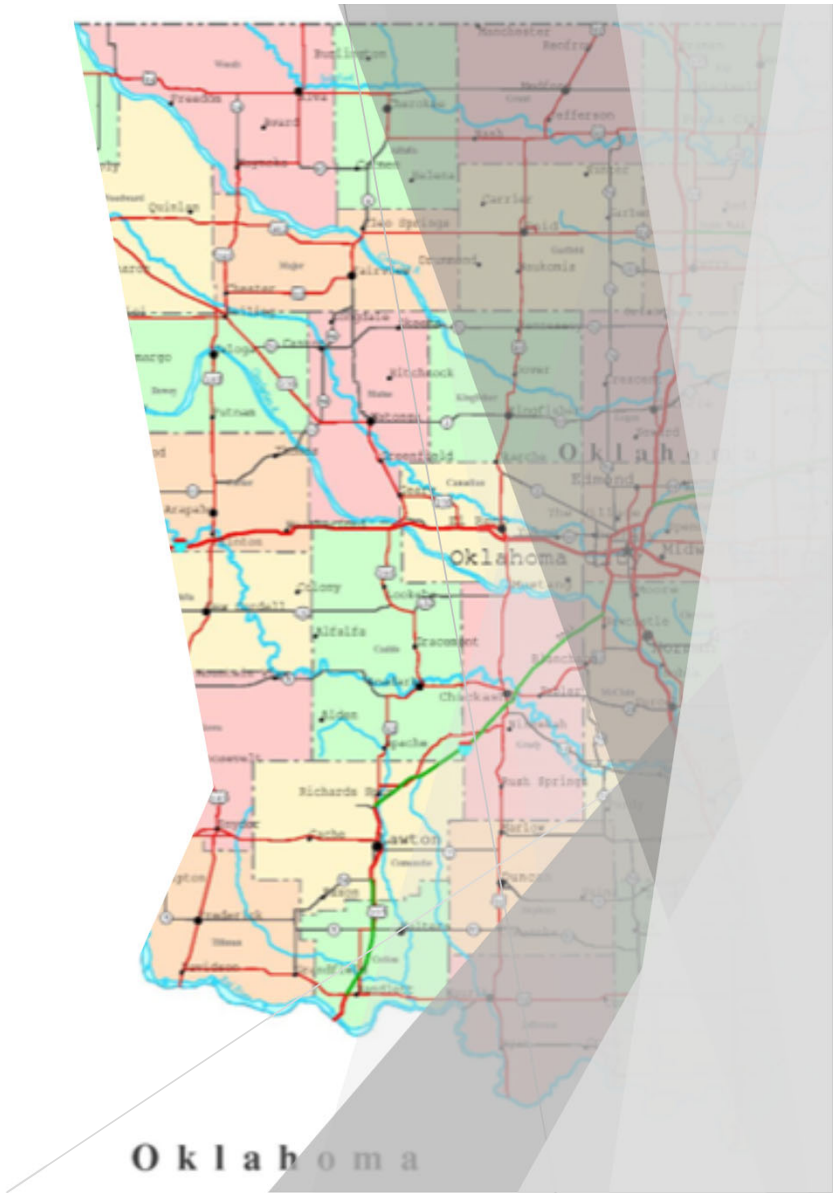


Approach B: Volumetric Design with Performance Optimization



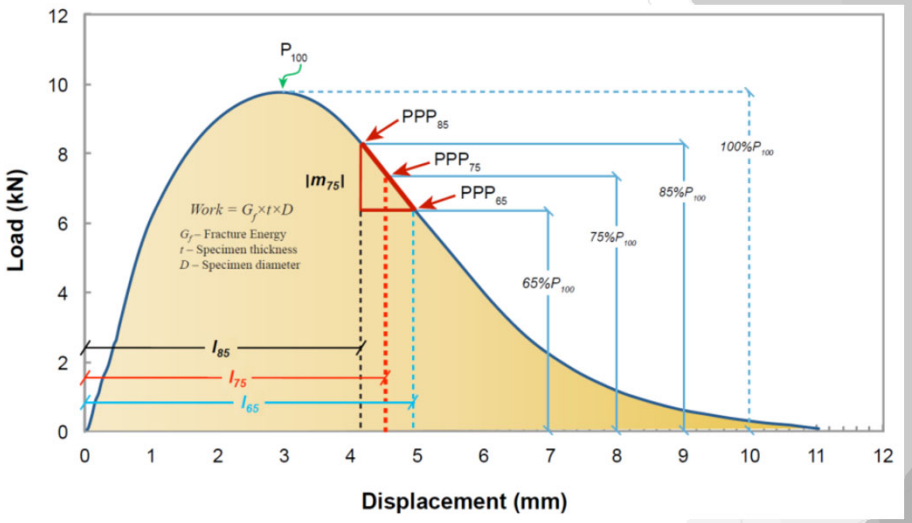
Phase 3 – 2023 Pilot Projects

- Expected outcomes
  - Confirm cracking test criteria
  - Field testing experience
  - Performance comparison with conventional Superpave
  - Confirm STA protocol of 4 hours
  - Close the gap between design and field testing
  - Determine final Spec for implementation
  - Long-term performance monitoring plan



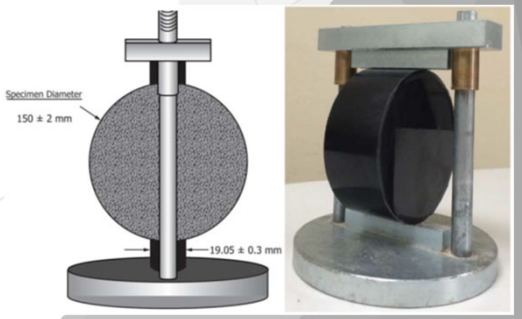
Phase 1 – Test Selection

- Ideal-CT
- Developed by Fujie Zhou, et al at TTI
- Benefits
  - Cost Effective, Simple, Practical, Efficient
  - Good Repeatability, Sensitivity, and Field Correlation
- ASTM D8225-19
- Indirect Tensile Strength
  - Min 3 replicates
  - 150mm diameter x 62 mm height specimen
  - Target air voids 7.0 ± 0.5%
  - 50 ± 2.0 mm/min load rate
  - 25°C Testing Temperature
  - 2 hours ± 10 minutes conditioning
  - Measure Load and Displacement



$$CT_{index} = \frac{t}{62} x \frac{l_{75}}{D} x \frac{G_f}{|m_{75}|} x 10^6$$

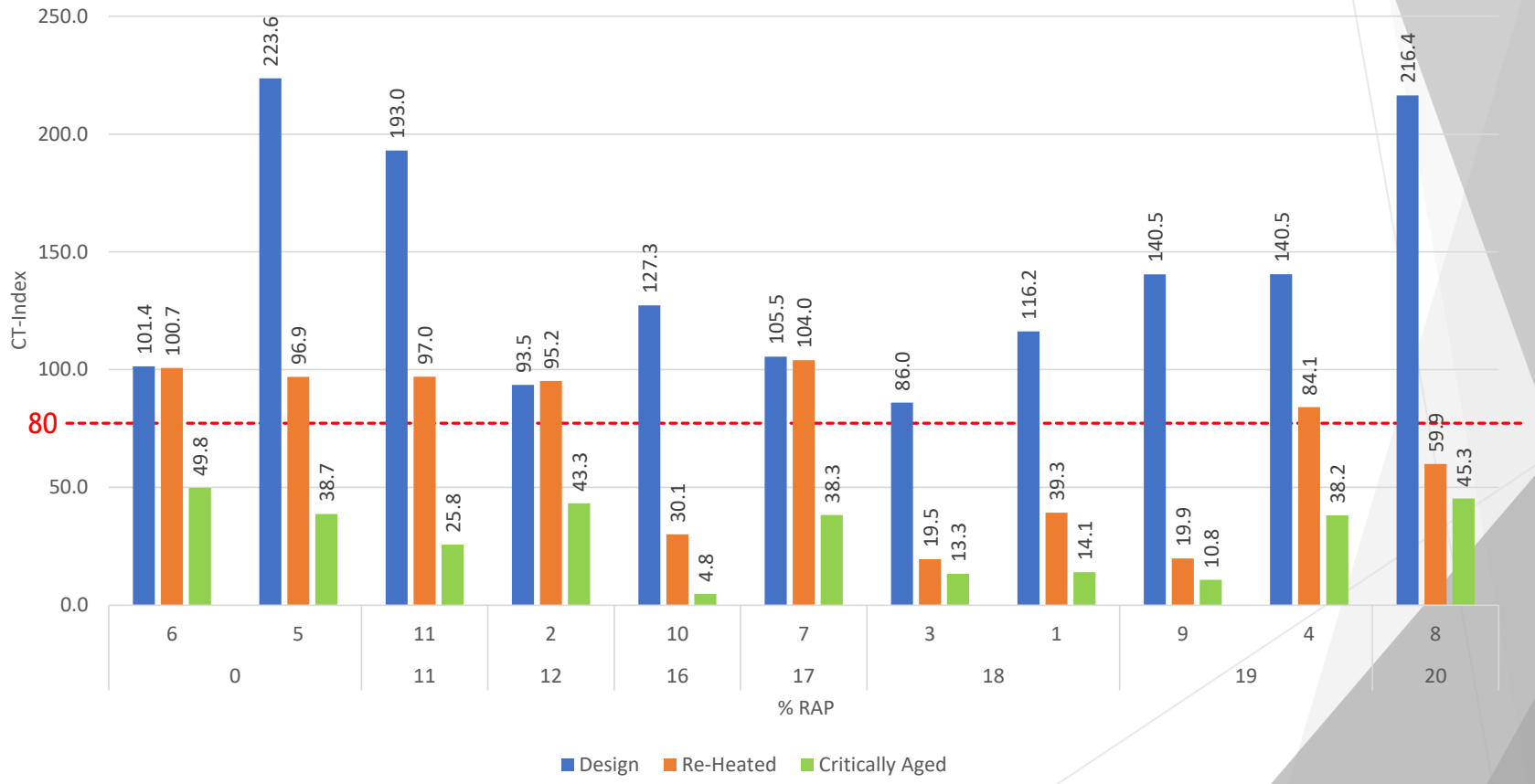
$$|m_{75}| = \left| \frac{P_{85} - P_{65}}{l_{85} - l_{65}} \right|$$



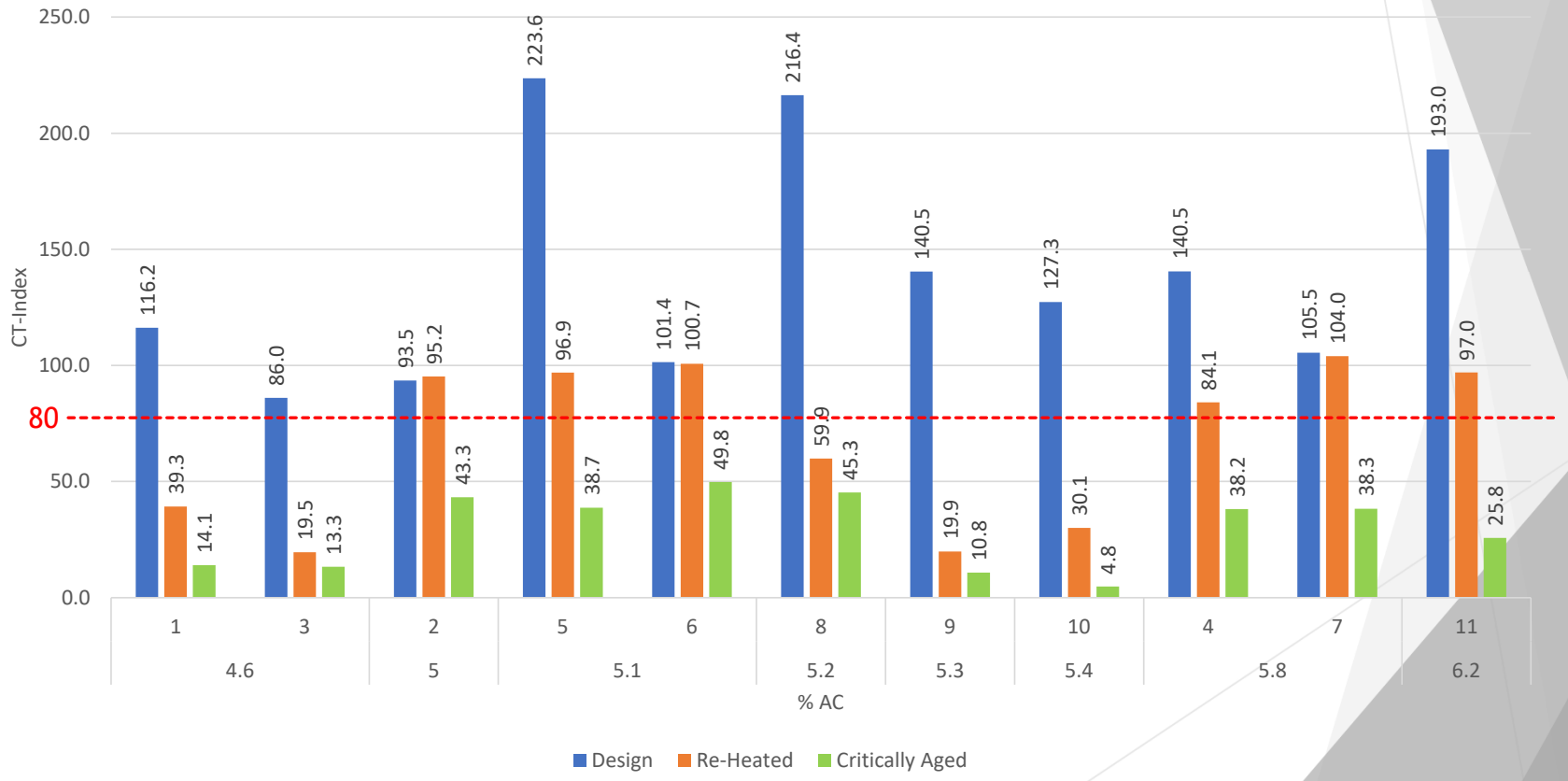
Phase 2 – Proof of Concept

- First BMD Special Provision
  - Evaluate the feasibility of BMD with Ideal-CT
  - RAP up to 40% for intermediate and base mixes with softer binder
  - RAP up to 20% for surface mixes with softer binder
  - Allow the use of rejuvenators and WMA
  - Flexible volumetric requirements
    - Lab Molds N_{des} – 96.0 to 97.0 % of Gmm
    - Field Density 92.0 to 98.0 % Gmm for 1.0 Pay Factor
- 11 Pilot projects in 2022

2022 Pilot Projects Results – By % RAP



2022 Pilot Projects Results – By % AC



2022 Pilot Projects Results – HWTT