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Introduction to BMD

A Roadmap to Implementation

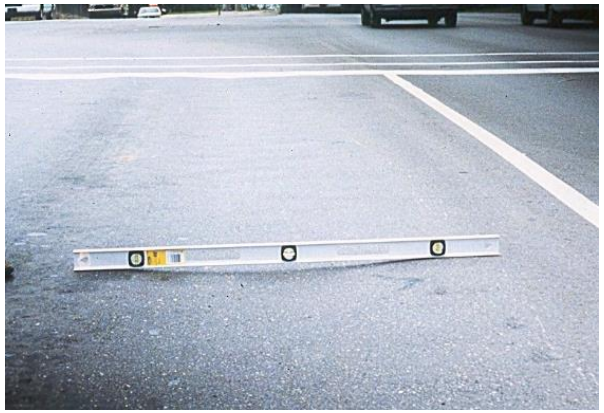
Asphalt Pavement Association of Michigan

Feb 23, 2021

Balanced Mix Design Definition

Balanced Mix Design has been defined 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."



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Mix Performance Testing: 20+ Years ago

Performance tests were supposed to be included in Superpave

- Superpave Shear Tester (SST)
- Superpave IDT

Equipment was purchased for Regional Superpave Centers, but the tests were too complicated and cost too much to implement for routine use.

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What was the primary distress concern 20 years ago?

In the early years of Superpave implementation, most attention was focused on rutting.

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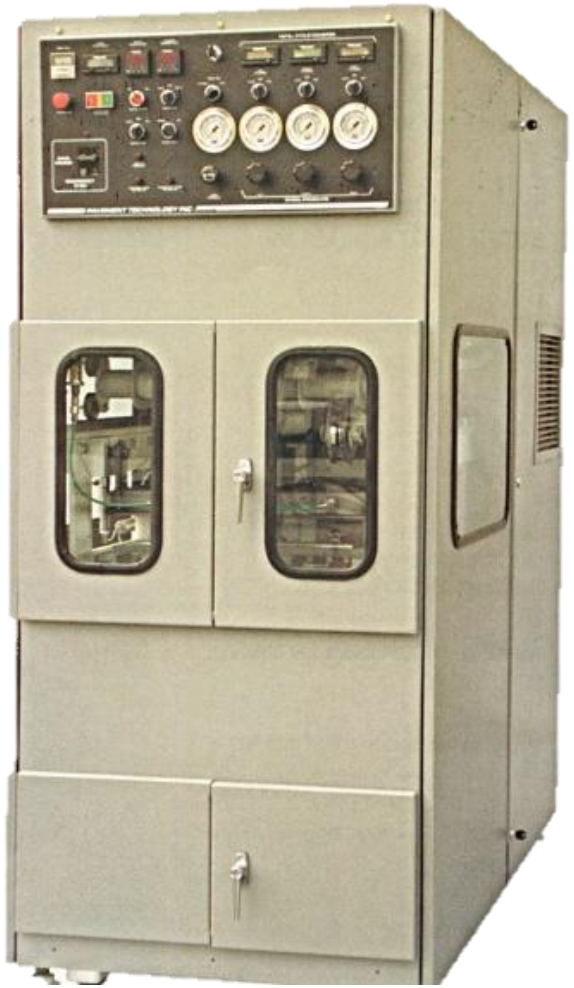
The Asphalt Pavement Analyzer



- Originally developed as the Georgia Loaded Wheel Tester for rutting
- APA Users Group
- AASHTO standard developed (T 340)
- Use has declined in recent years as the Hamburg Wheel Tracking Test has become more popular

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The need for mixture cracking tests rises

- A decade after Superpave implementation, many states realized mixes were dry and we needed to improve durability.
- Fragmented efforts to tweak volumetric criteria
- Research focus on WMA, RAP, RAS, REOB, etc. all pointed to the need for reliable cracking tests for mix design. Fragmented research, no national projects focused on cracking tests.

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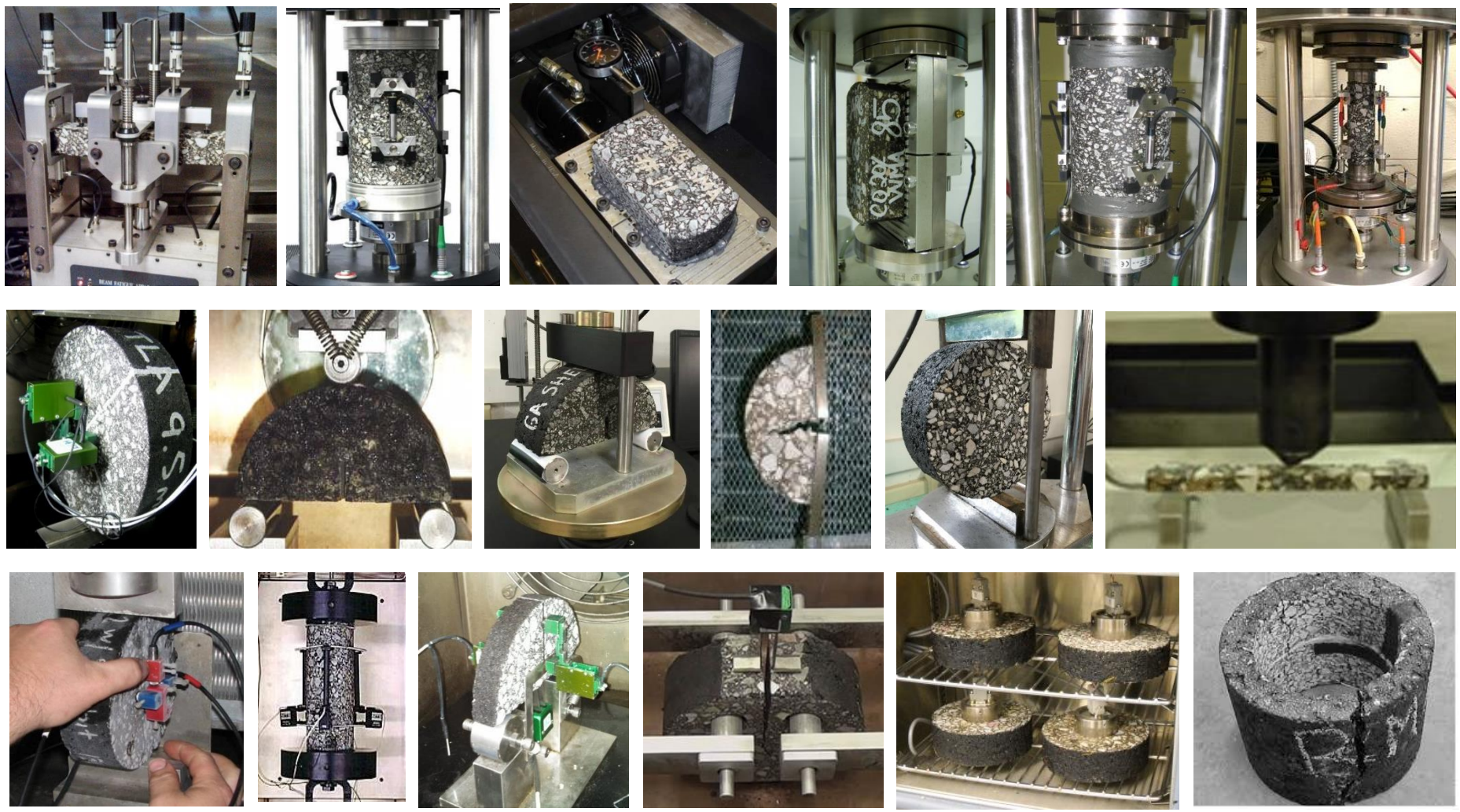
The proliferation of cracking tests



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Why Volumetric Testing is Inadequate.

- Volumetric properties do not tell us anything about the quality of the binder or about the interactions of different binder components and additives.
- VMA is dependent on the aggregate bulk specific gravity G_{sb} which is not a reliable property
  - Some states Gse instead of Gsb which is simply wrong
  - G_{sb} of source materials are subject to change over time, but not often verified.
  - G_{sb} has a low level of precision
  - G_{sb} of RAP aggregate is questionable for some materials

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With the current volumetric mix design system…

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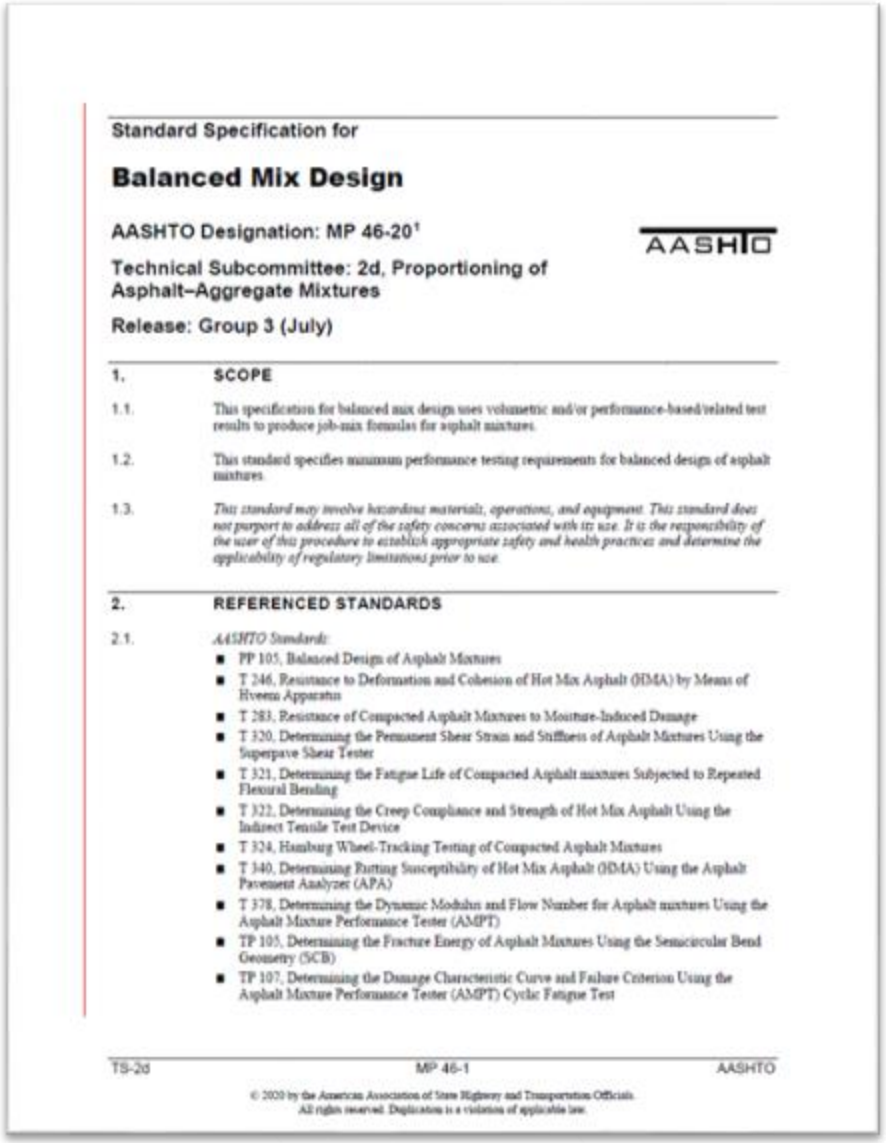
Motivations to Use BMD

1. Dissatisfaction with performance of current asphalt mixes
2. Desire to continuously improve the performance of asphalt mixes
3. Desire to utilize higher recycled materials contents
4. Realization that volumetrics criteria are insufficient
5. Desire to allow mix designers to be innovative in optimizing their materials to meet performance criteria

BMD Framework Standards



Standard Specification for

Balanced Mix Design

AASHTO Designation: MP 46-20[1]

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

Release: Group 3 (July)

AASHTO

1. SCOPE

1.1. This specification for balanced mix design uses volumetric and/or performance-based/related test results to produce job-mix formulas for asphalt mixtures.

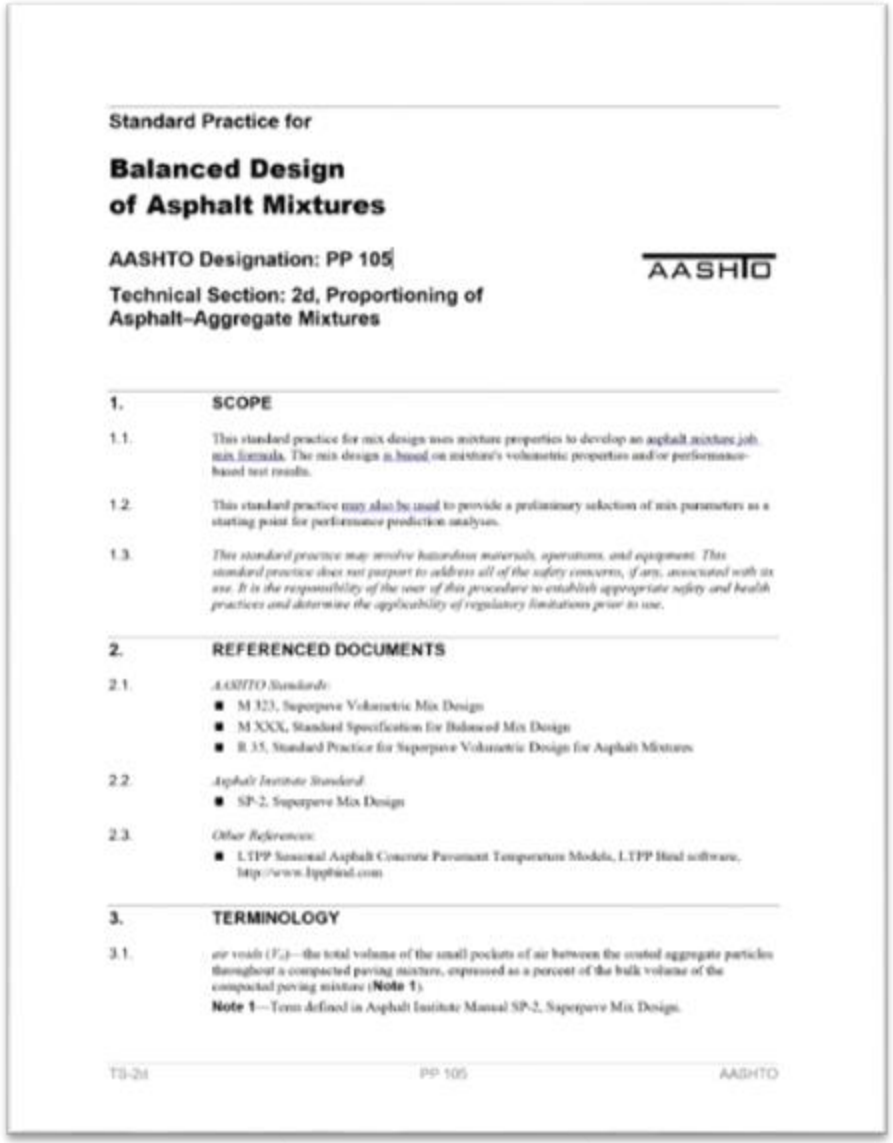
1.2. This standard specifies minimum performance testing requirements for balanced design of asphalt mixtures.

1.3. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED STANDARDS

2.1. *AASHTO Standards:*

- PP 105, Balanced Design of Asphalt Mixtures
- T 246, Resistance to Deformation and Cohesion of Hot Mix Asphalt (HMA) by Means of Hveem Apparatus
- T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
- T 320, Determining the Permanent Shear Strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester
- T 321, Determining the Fatigue Life of Compacted Asphalt mixtures Subjected to Repeated Flexural Bending
- T 322, Determining the Creep Compliance and Strength of Hot Mix Asphalt Using the Indirect Tensile Test Device
- T 324, Hamburg Wheel-Tracking Testing of Compacted Asphalt Mixtures
- T 340, Determining Rutting Susceptibility of Hot Mix Asphalt (HMA) Using the Asphalt Pavement Analyzer (APA)
- T 378, Determining the Dynamic Modulus and Flow Number for Asphalt mixtures Using the Asphalt Mixture Performance Tester (AMPT)
- TP 105, Determining the Fracture Energy of Asphalt Mixtures Using the Semicircular Bend Geometry (SCB)
- TP 107, Determining the Damage Characteristic Curve and Failure Criterion Using the Asphalt Mixture Performance Tester (AMPT) Cyclic Fatigue Test



Standard Practice for

Balanced Design of Asphalt Mixtures

AASHTO Designation: PP 105

Technical Section: 2d, Proportioning of Asphalt–Aggregate Mixtures

AASHTO

1. SCOPE

1.1. This standard practice for mix design uses mixture properties to develop an asphalt mixture job mix formula. The mix design is based on mixture's volumetric properties and/or performance-based test results.

1.2. This standard practice may also be used to provide a preliminary selection of mix parameters as a starting point for performance prediction analyses.

1.3. *This standard practice may involve hazardous materials, operations, and equipment. This standard practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*

- M 323, Superpave Volumetric Mix Design
- M XXX, Standard Specification for Balanced Mix Design
- R 35, Standard Practice for Superpave Volumetric Design for Asphalt Mixtures

2.2. *Asphalt Institute Standard:*

- SP-2, Superpave Mix Design

2.3. *Other References:*

- LTPP Seasonal Asphalt Concrete Pavement Temperature Models, LTPP Bind software, http://www.ltppbind.com

3. TERMINOLOGY

3.1. *air voids* (V_a)—the total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture (**Note 1**).

Note 1—Term defined in Asphalt Institute Manual SP-2, Superpave Mix Design.

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8 Steps to BMD Implementation

1. Understanding the Why and Benefits of BMD and Performance Specifications
2. Overall Planning
3. Selecting Performance Tests
4. Performance Test Equipment: Acquiring, Managing Resources, Training & Evaluating
5. Establishing Baseline Data
6. Specification and Program Development
7. Training, Certification & Accreditations
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Cracking Group Experiments

MnROAD

Low-temperature cracking

NCAT Test Track

Top-down cracking

Objective: to determine which lab tests provide results that best match field performance

MnROAD
Safer, Smarter, Sustainable Pavements Through Innovative Research

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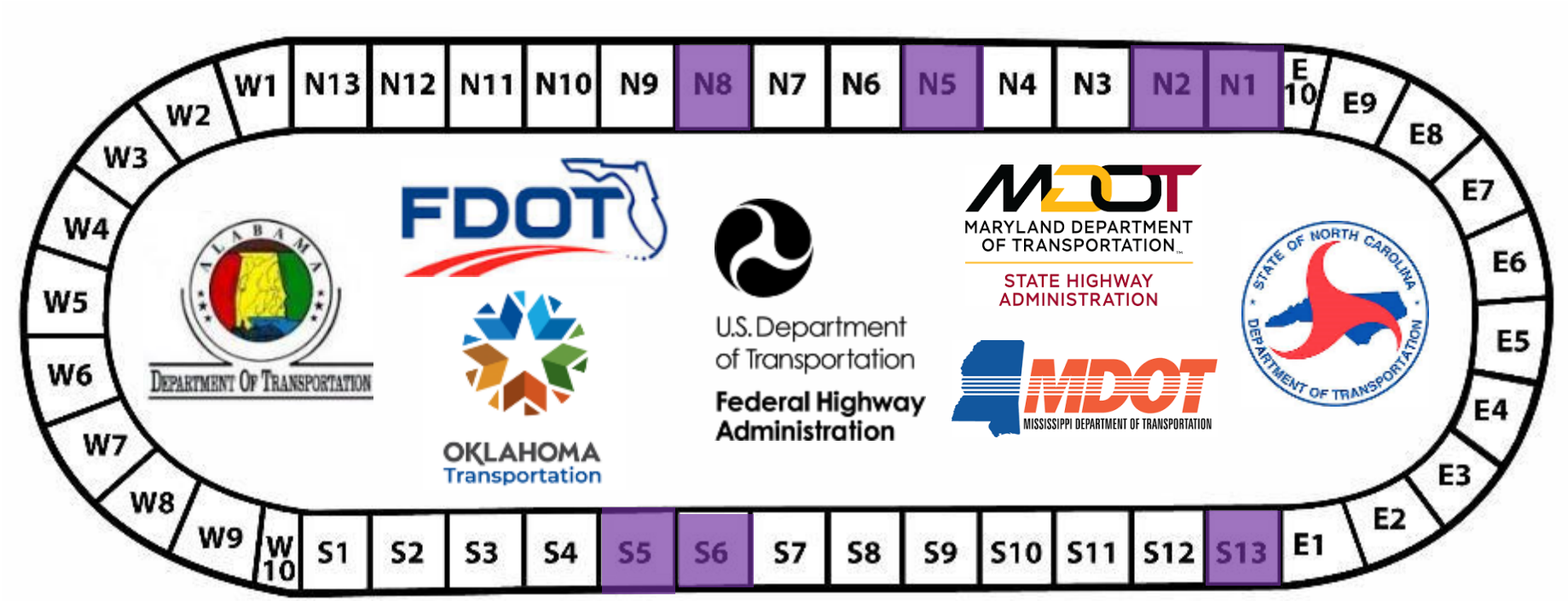

Surface Layer	1.5”
HiMA mix Intermediate Layer	2.25”
HiMA mix Base Layer	2.25”
Granular base	6”
Stiff track subgrade	infinite

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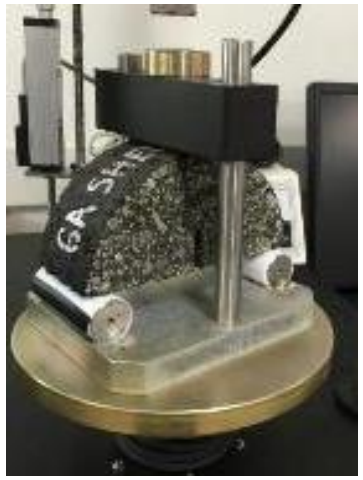
Selected Top-Down Cracking Tests

SCB-LA



I-FIT

OT-TX

OT-NCAT

IDEAL-CT

AMPT Cyclic Fatigue

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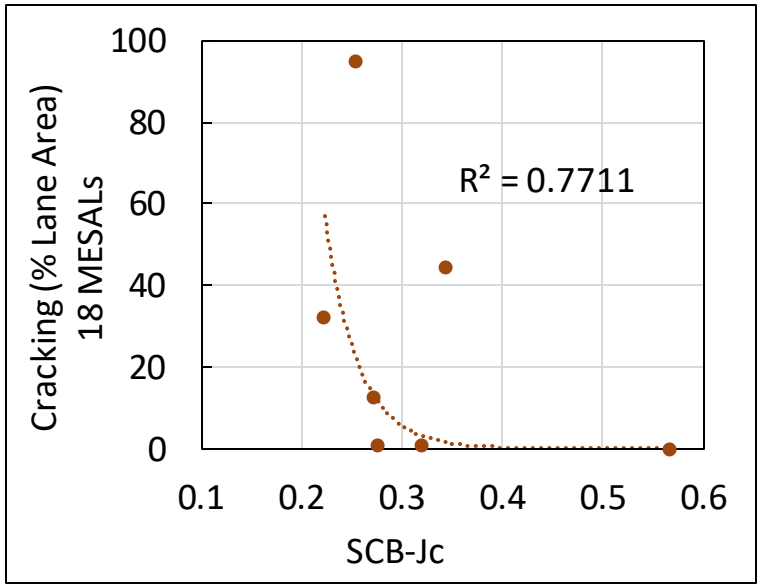
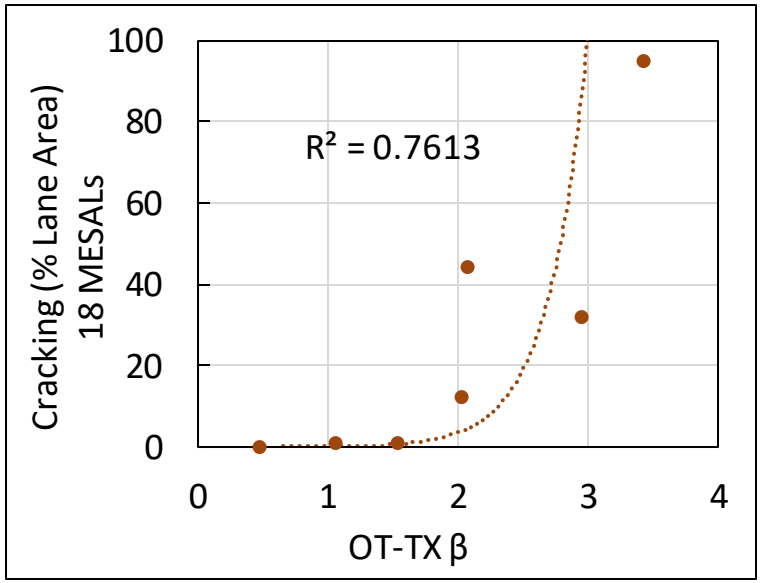
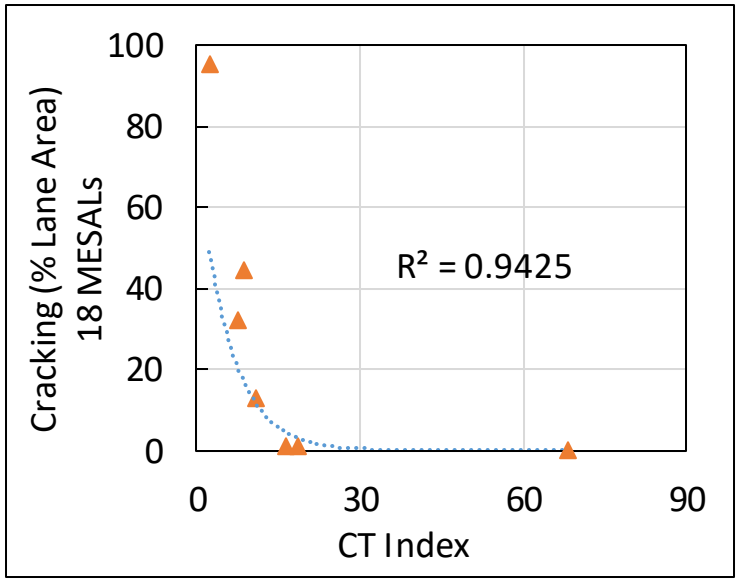
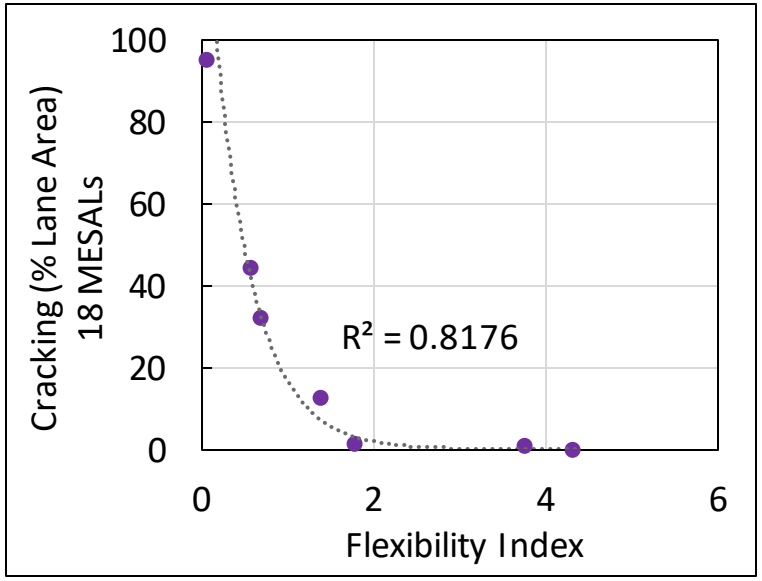
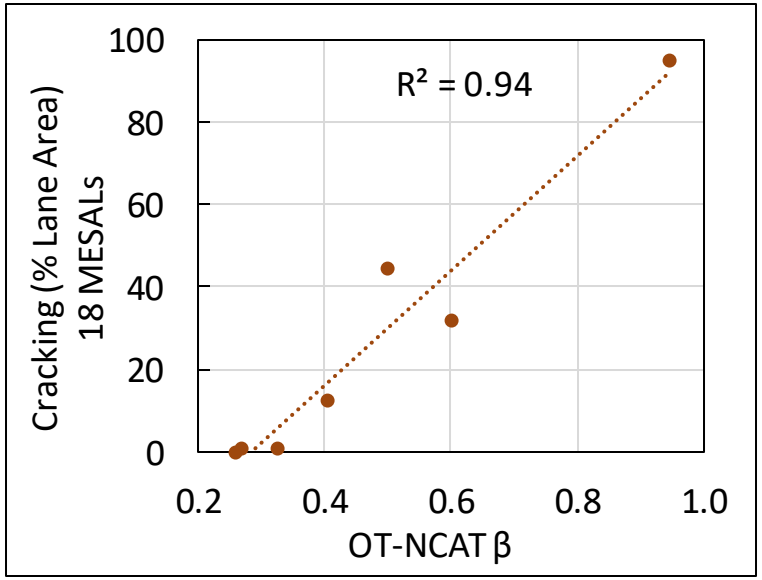
PMLC Critically Aged 8 hrs. @ 135°C

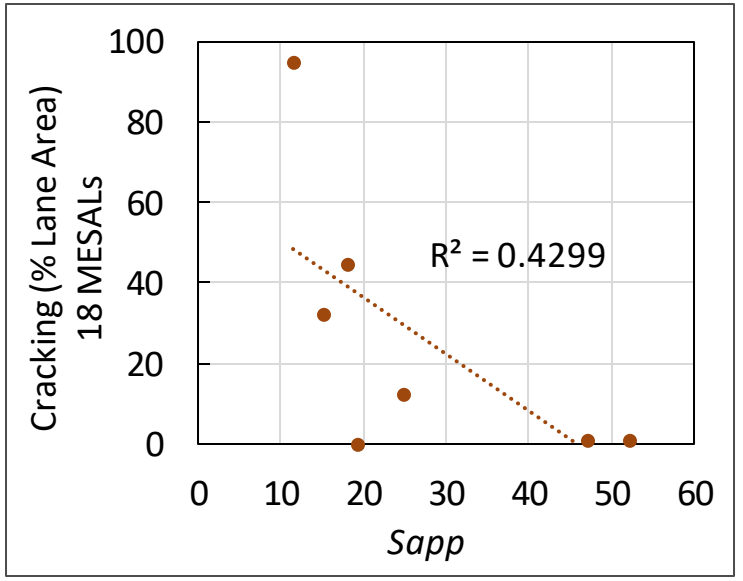












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MDOT Michigan Department of Transportation

Illinois Department of Transportation

NEW YORK STATE OF OPPORTUNITY. Department of Transportation

WISCONSIN DEPARTMENT OF TRANSPORTATION

MINNESOTA DEPARTMENT OF TRANSPORTATION

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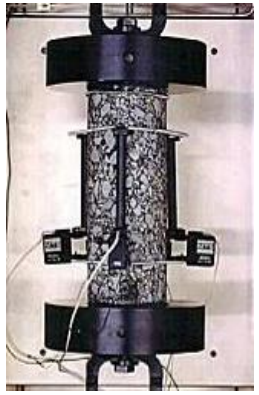
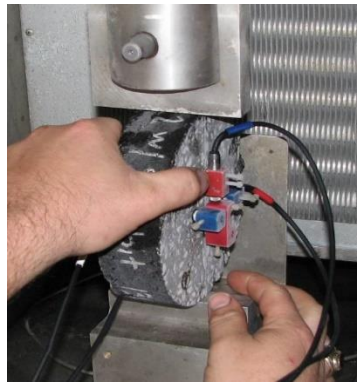
Selected Thermal Cracking Tests

Disk-Shaped Compact Tension

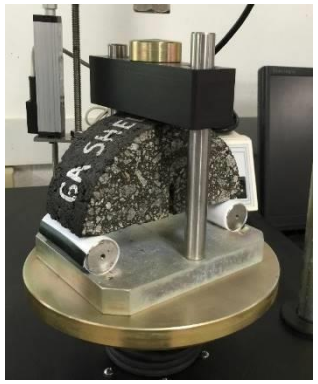


UTSST

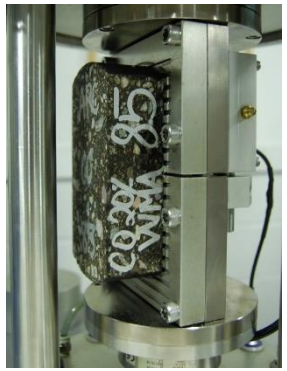
Semi-Circular Bend



IDT Creep Compliance



SCB-IL



OT-NCAT

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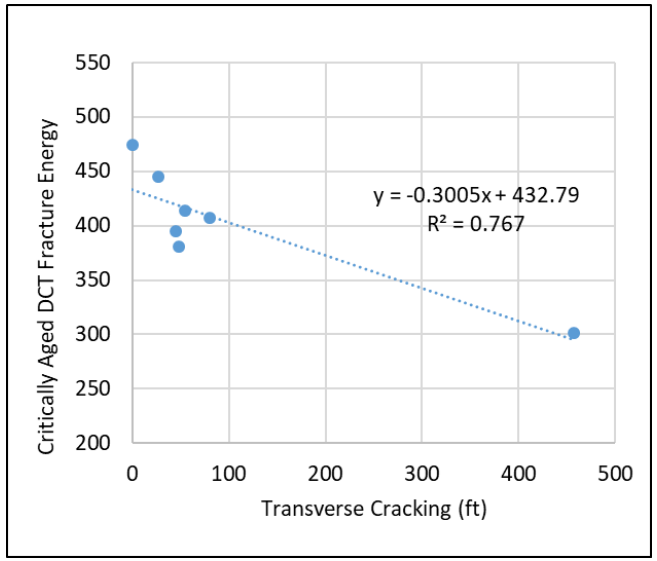
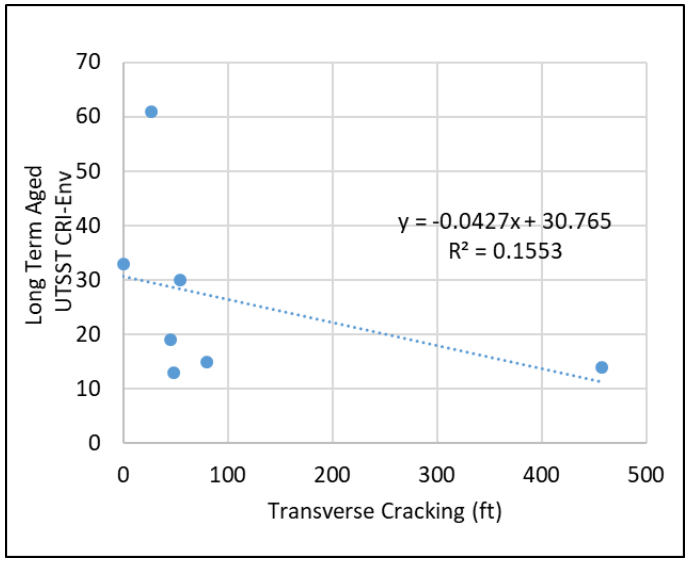
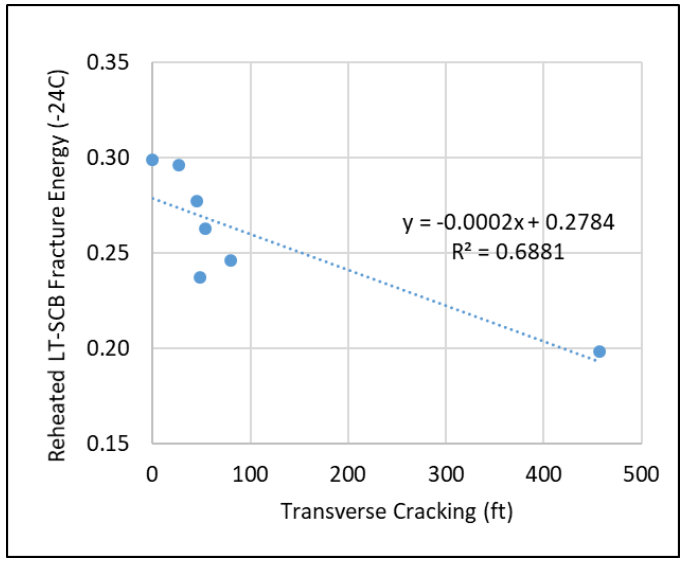
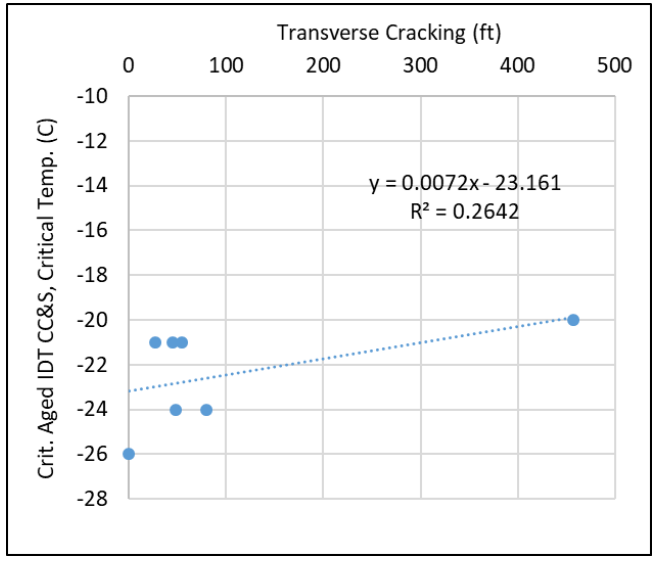
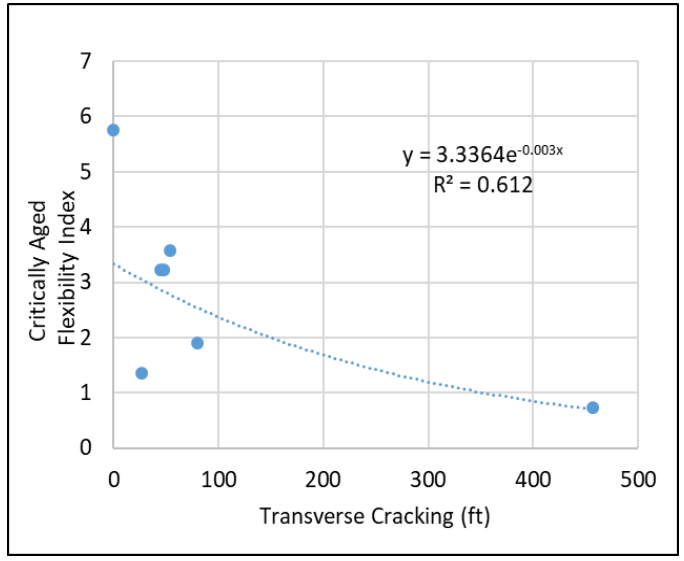
MnROAD Thermal Cracking Lab-Field Corr.

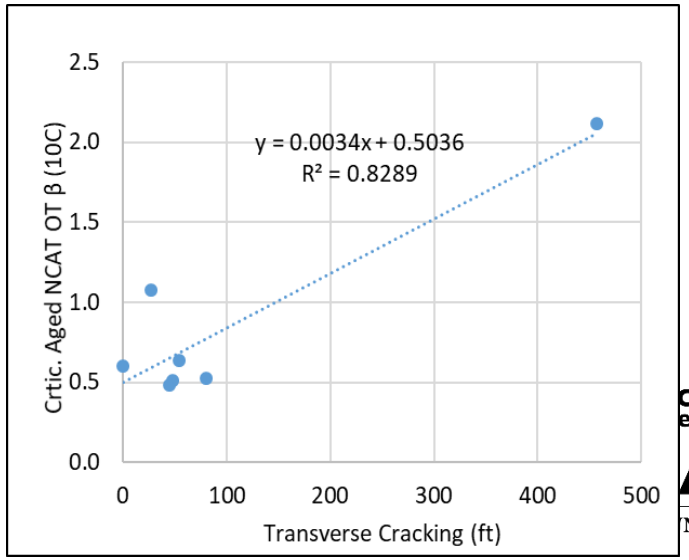












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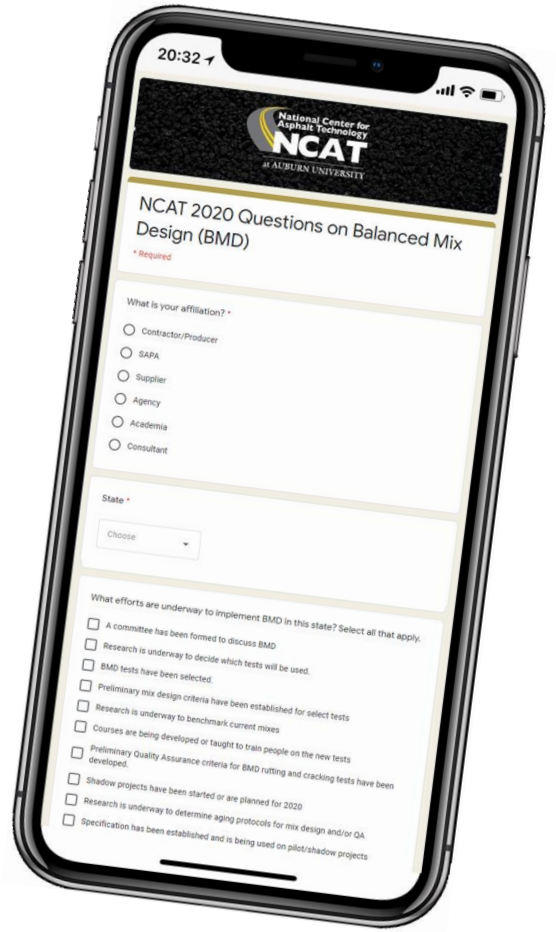
NCAT BMD Survey Summer 2020

- Very brief survey to gather BMD status of agencies across the US
- Responses from all stakeholder groups
  - Contractor/Producer
  - SAPA
  - Supplier
  - Agency
  - Academia
  - Consultant
- Responses from all 50 states



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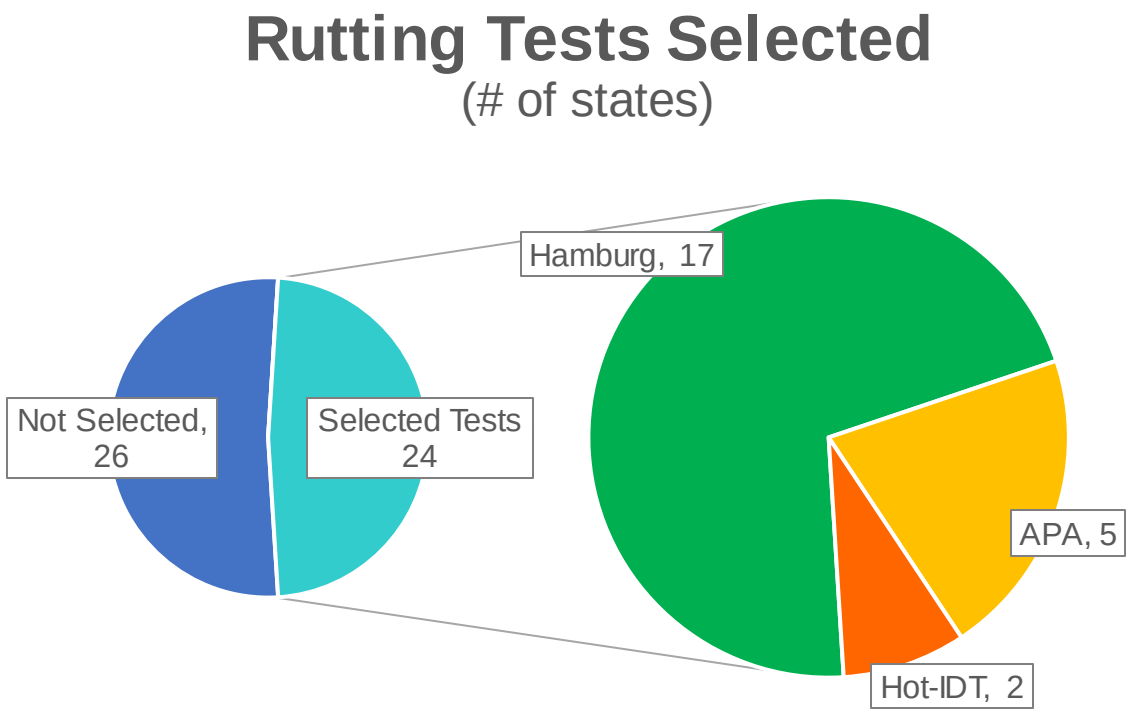
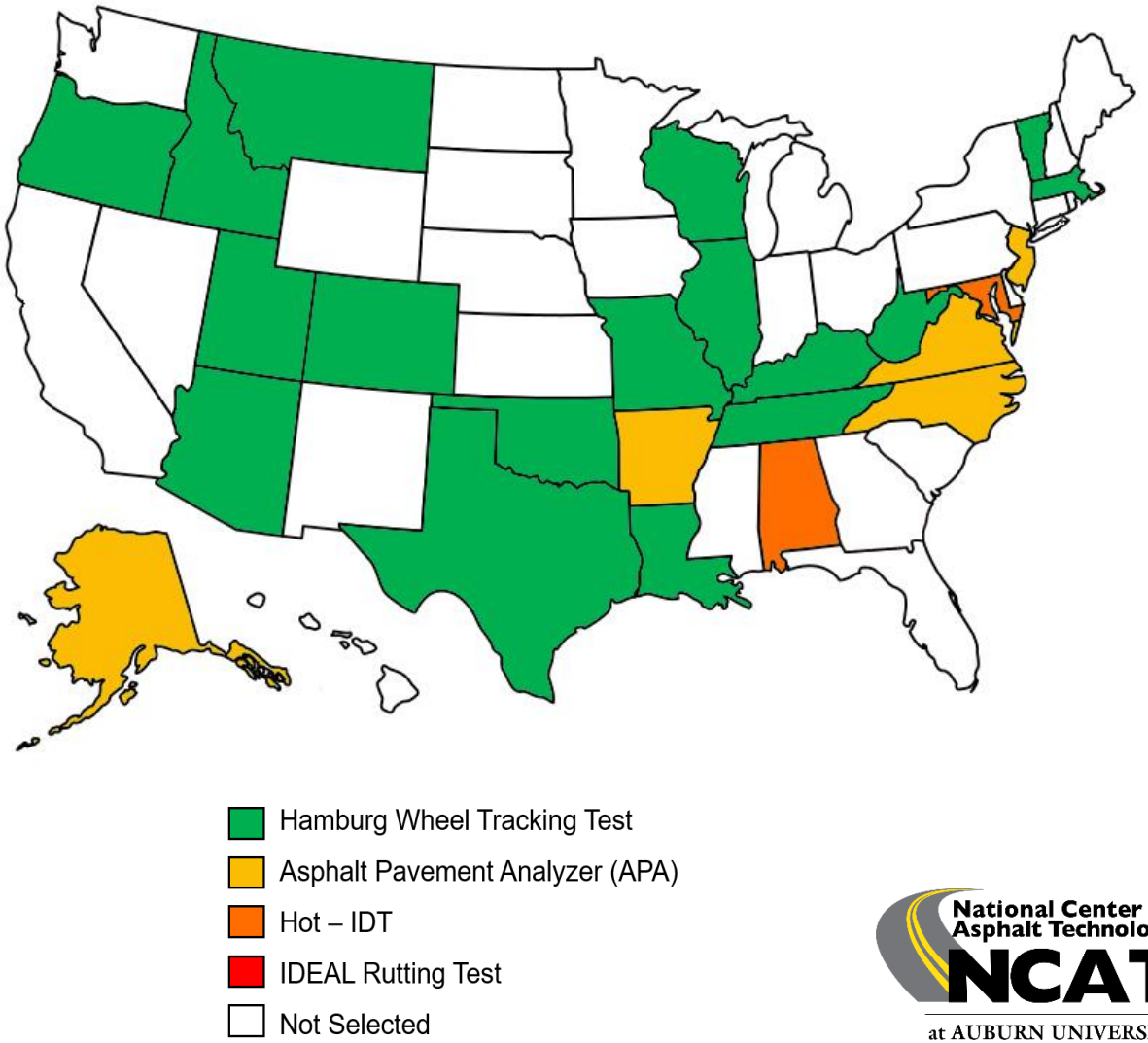
Rutting Tests





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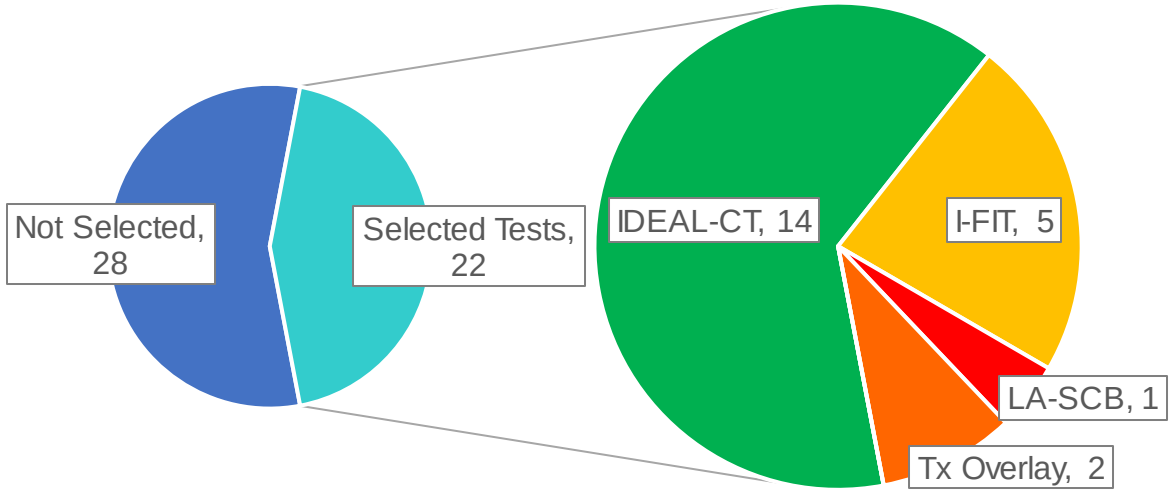
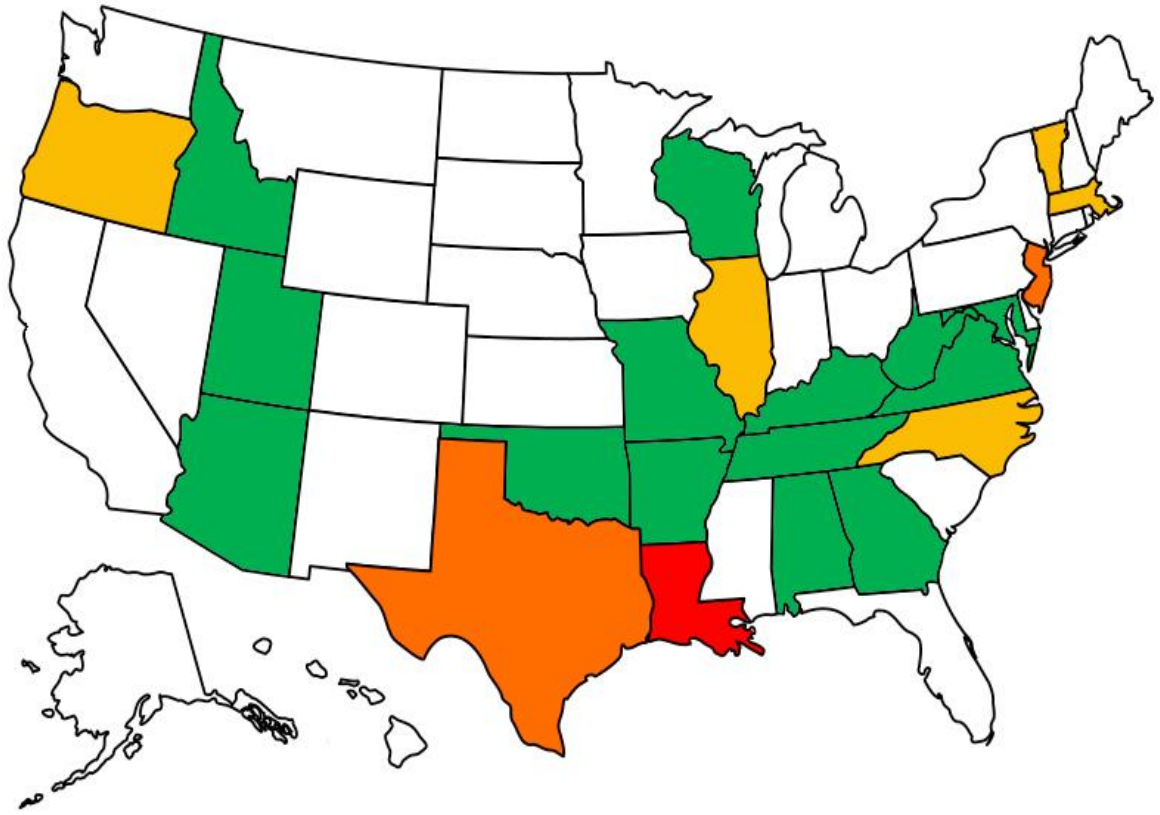
Load Related Cracking Tests





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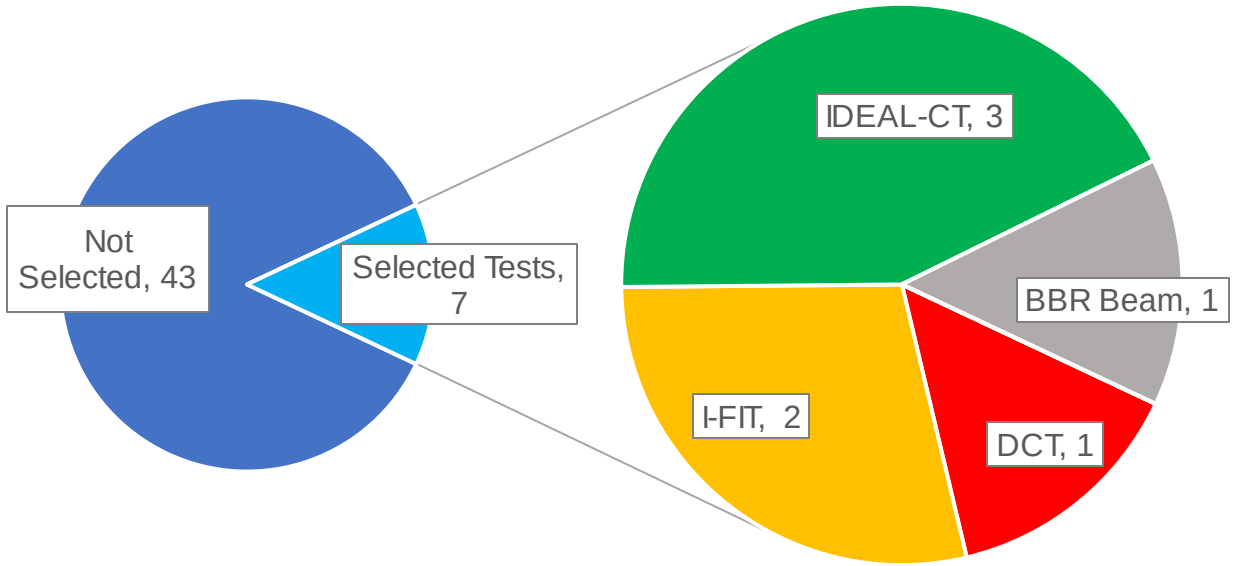
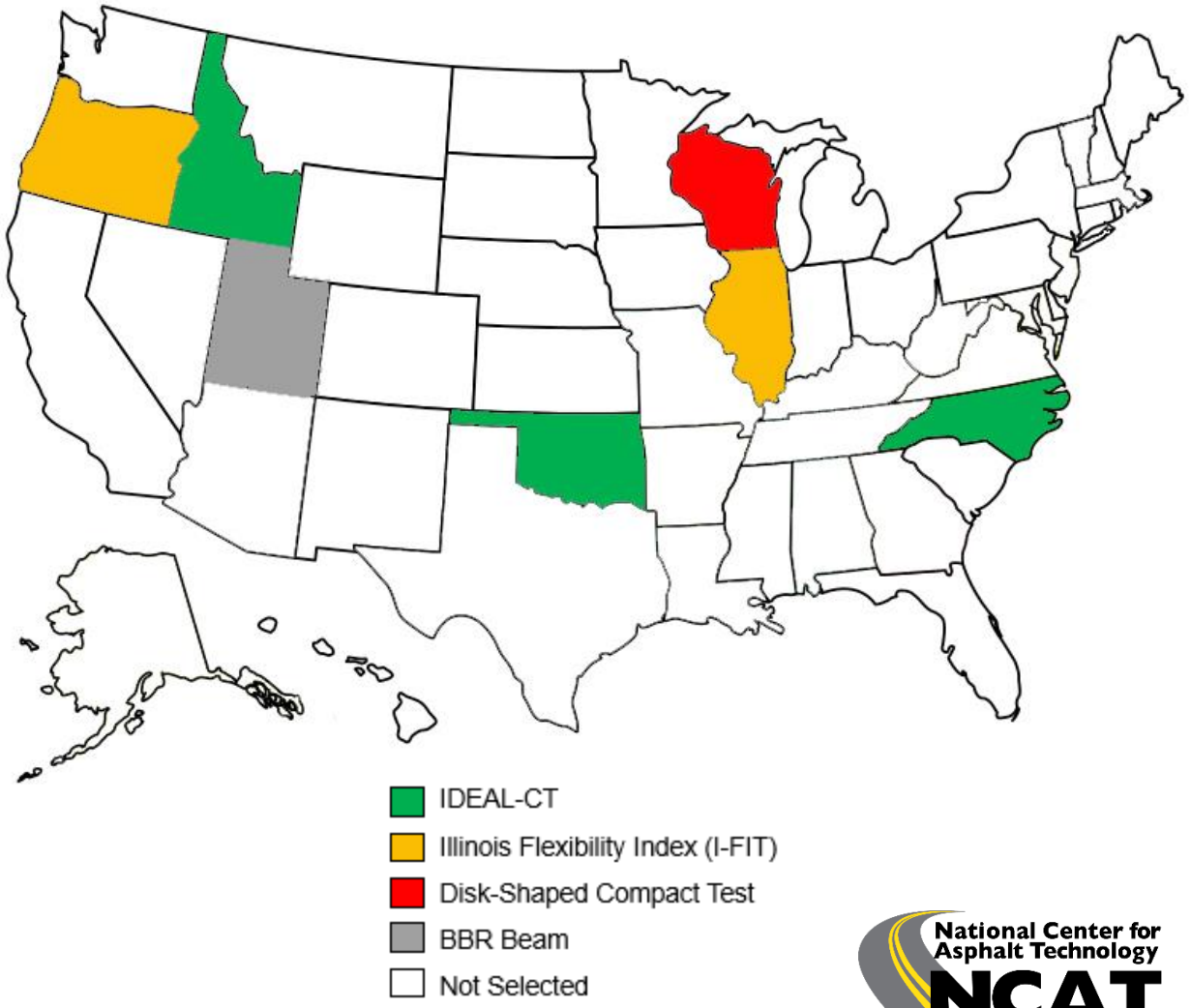
Thermal Cracking Tests





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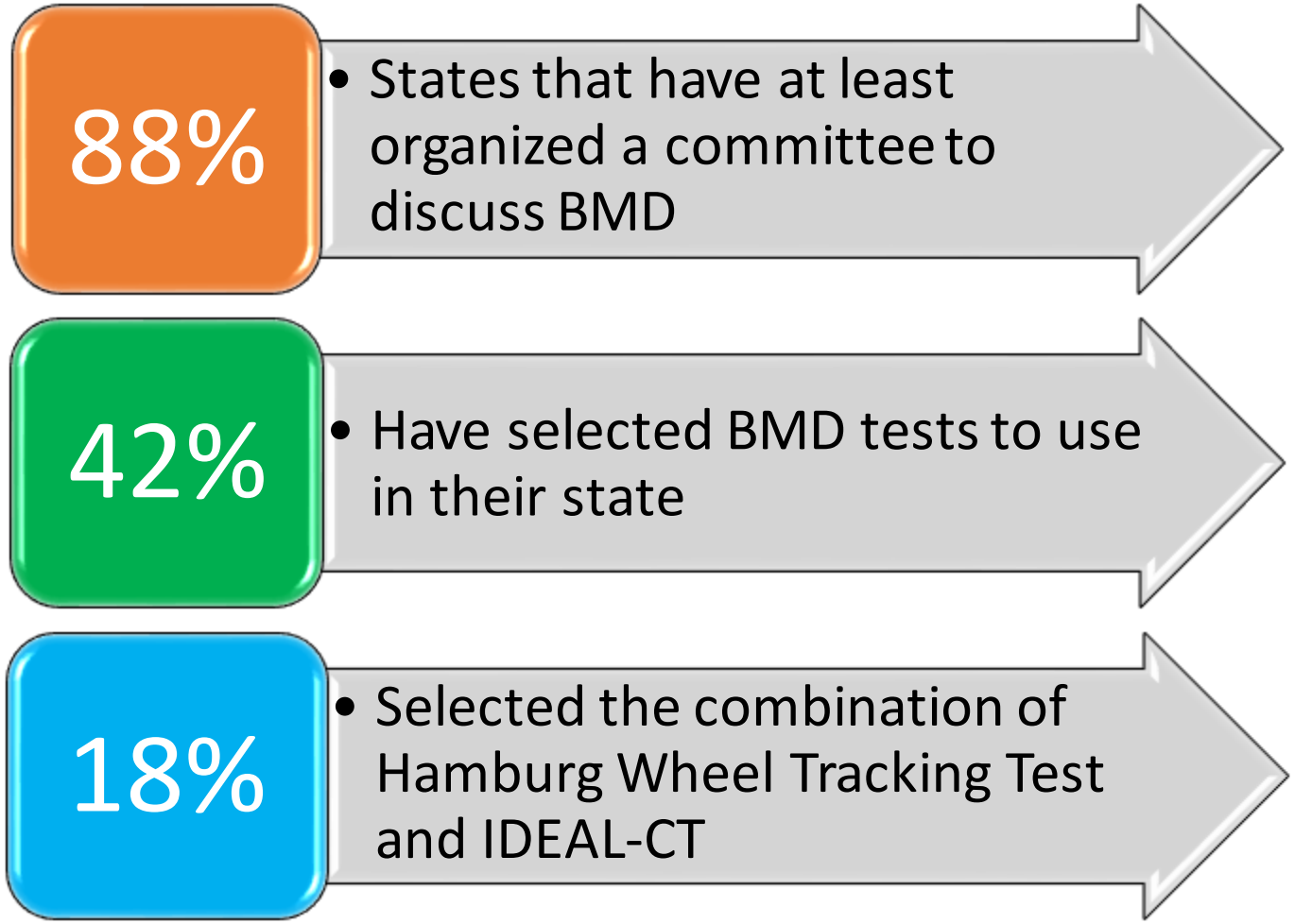
Major Takeaways from the Survey



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   a. Benchmarking
   b. Shadow Projects
6. Specification and Program Development
7. Training, Certification & Accreditations
8. Initial Implementation
   a. Pilot Projects

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Benchmarking

- A study to establish a database of test results of currently used mixtures
  - Lab produced mixtures → mix design criteria
  - Plant produced mixtures → acceptance criteria
- Generally preferred to conduct the study by a single lab to exclude between-lab variability
- Analysis
  - Distribution of results
  - Mix factors

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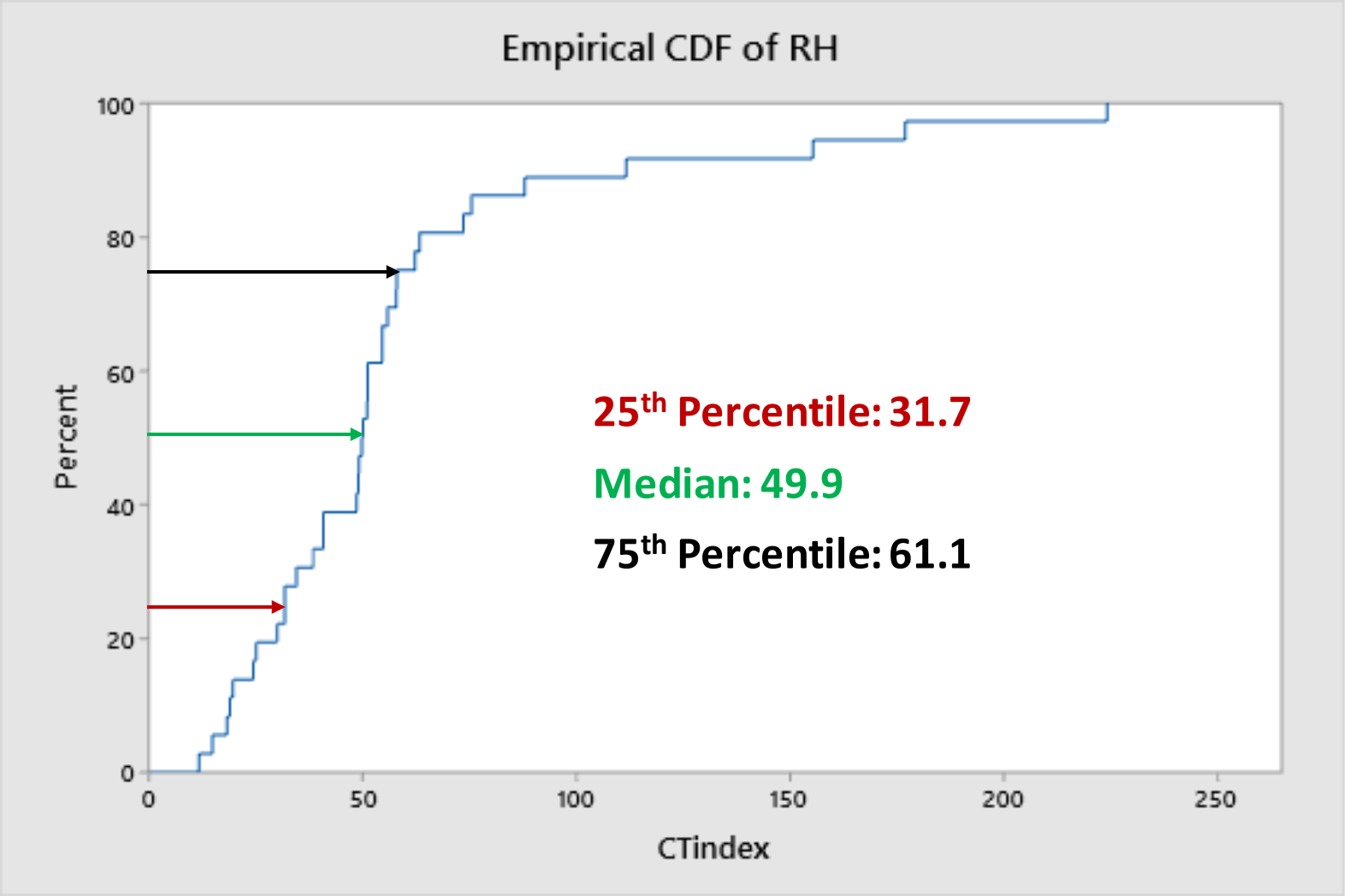
Benchmark Data – State "X"
Reheated IDEAL-CT Results



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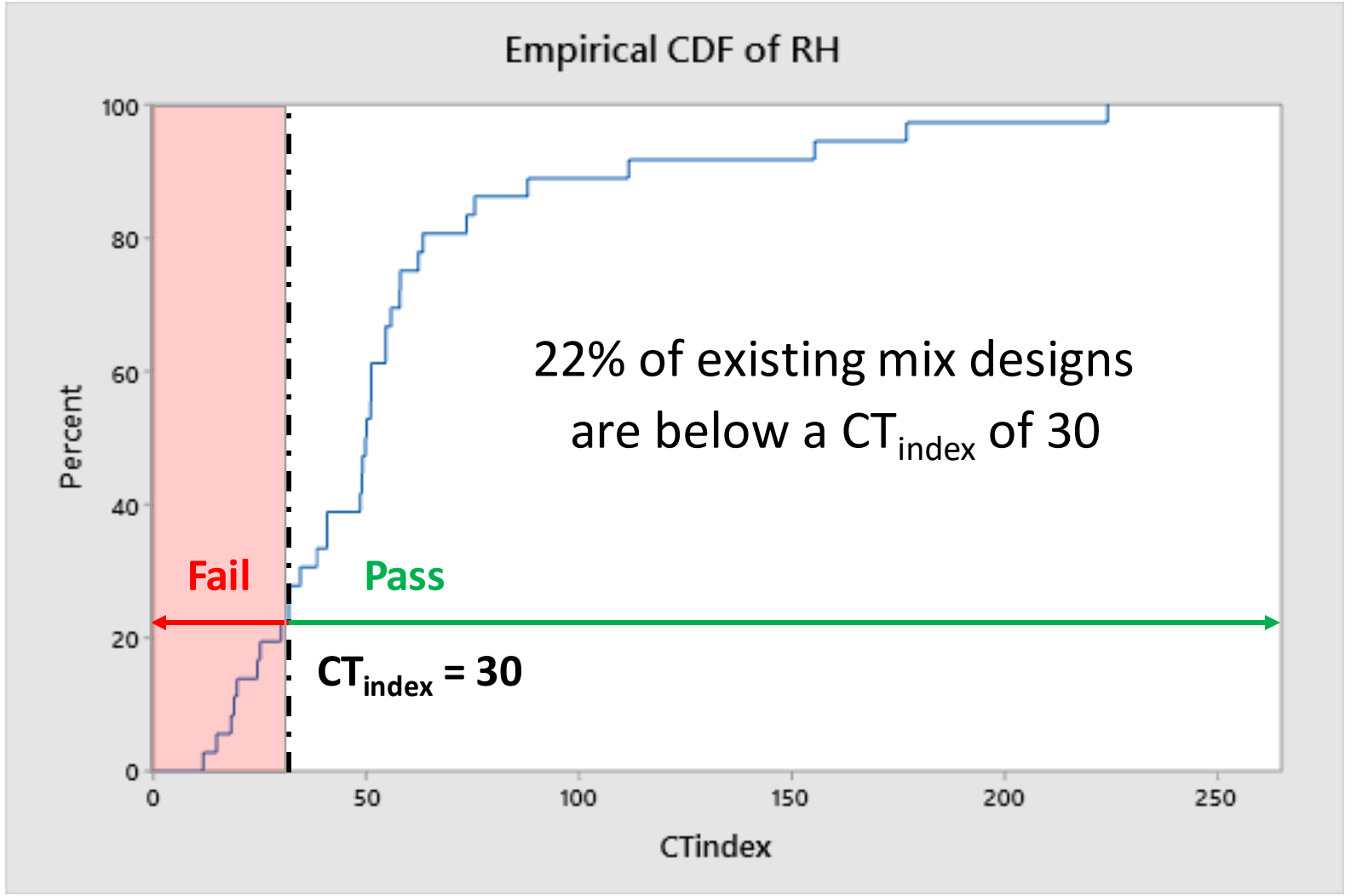
Benchmark Data – State "X"
Reheated IDEAL-CT Results



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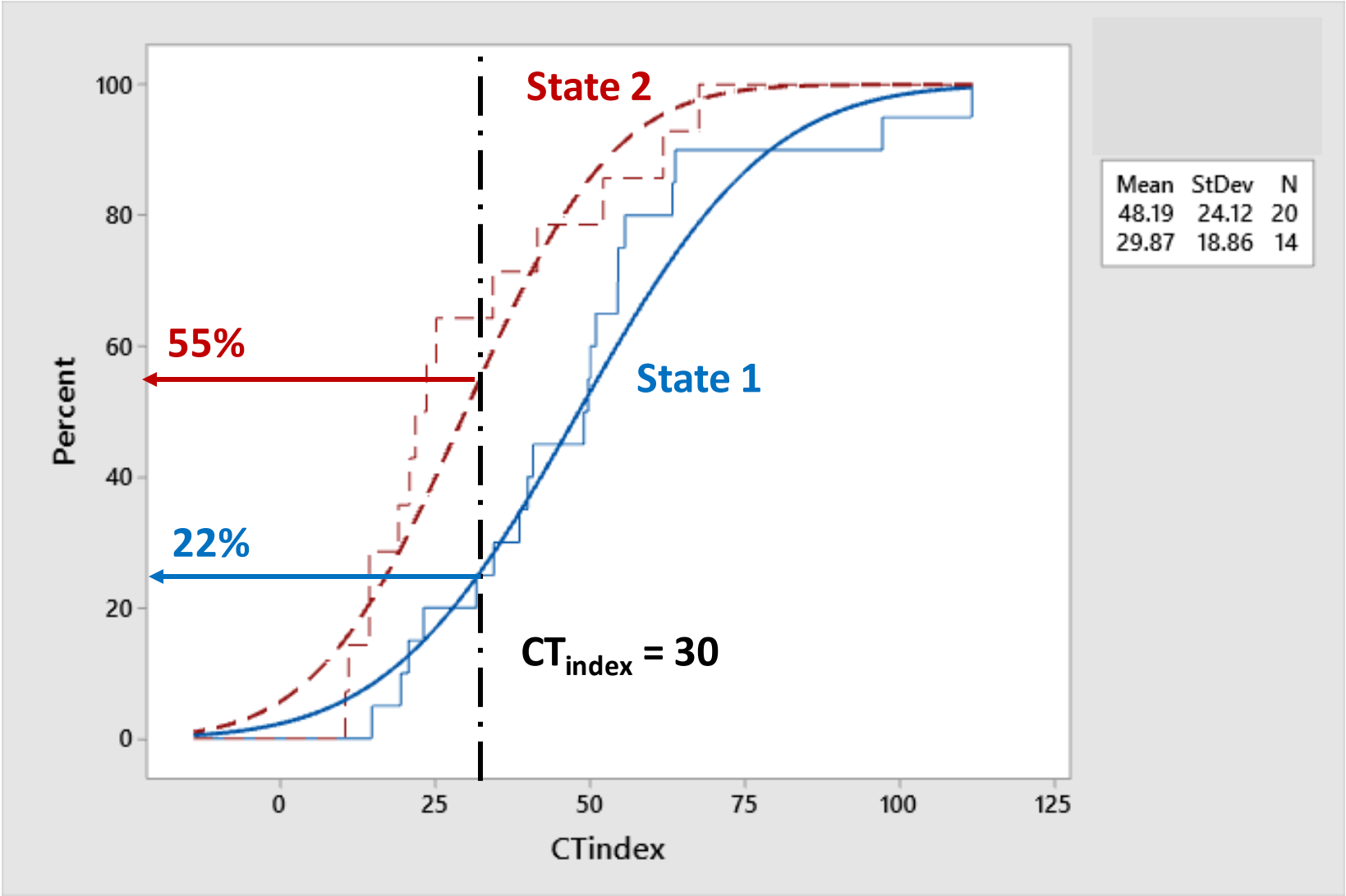
Reheated IDEAL-CT Results from Two Neighboring States



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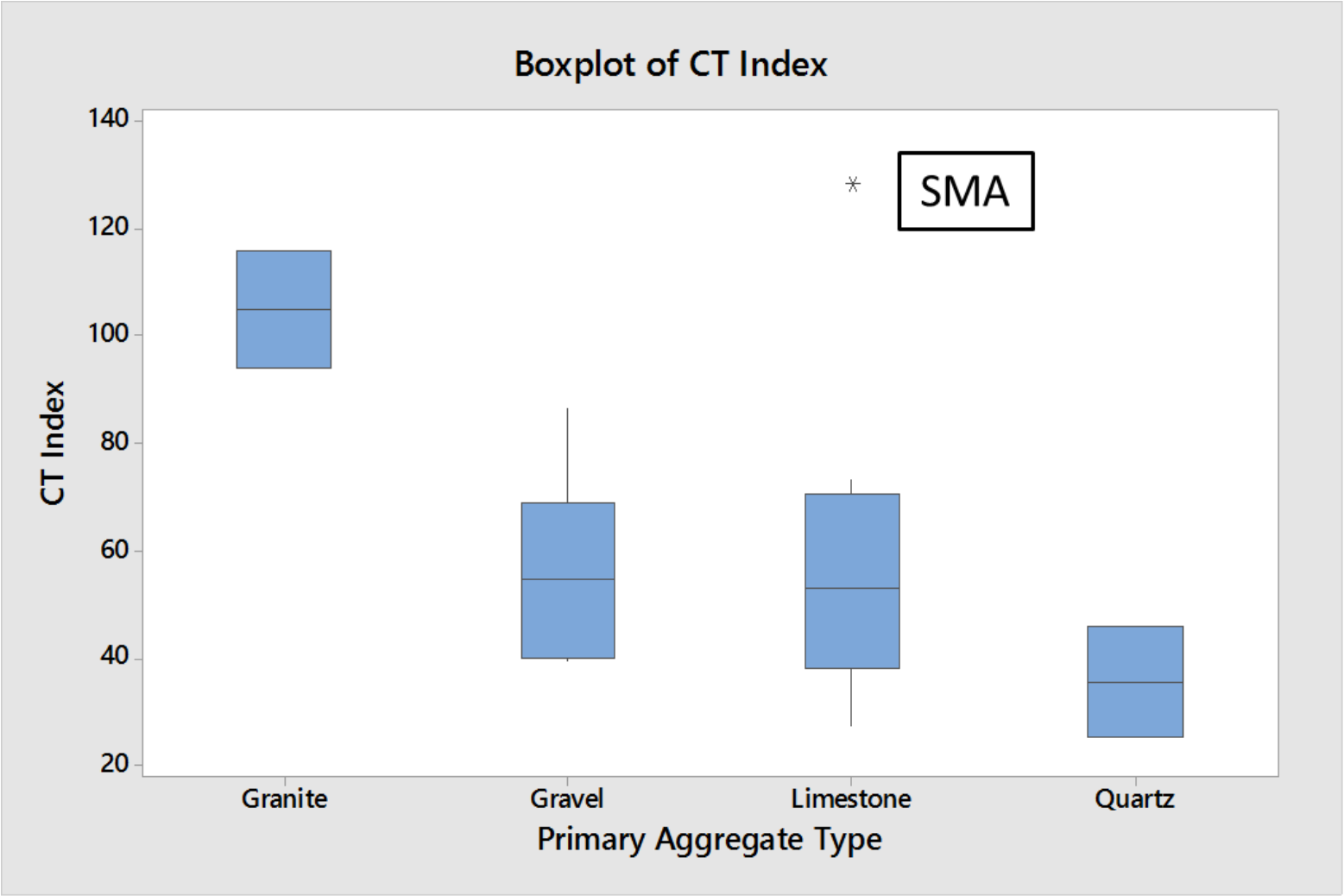
Benchmark Data Analysis
IDEAL-CT Results by Aggregate Type



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   a. Pilot Projects

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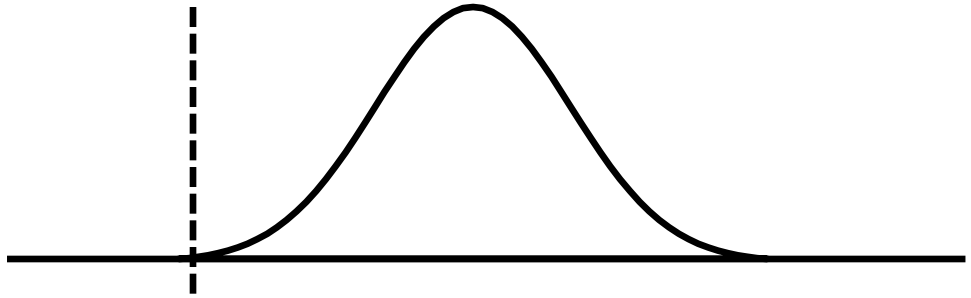
Definitions

- Shadow Project – a project on which additional tests are conducted at a frequency similar to existing AQCs to gather information on:
  - the logistics of conducting the tests in a production environment
  - production variability of the new test results
- The mixture is produced and accepted based in existing AQCs
- The new tests may be conducted by a lab different than one used on a regular project

Three Goals of Shadow Projects

1. Familiarize DOT and contractor personnel with the selected tests
2. Add to the database of test results from the benchmarking studies
3. To gather information on typical production variability



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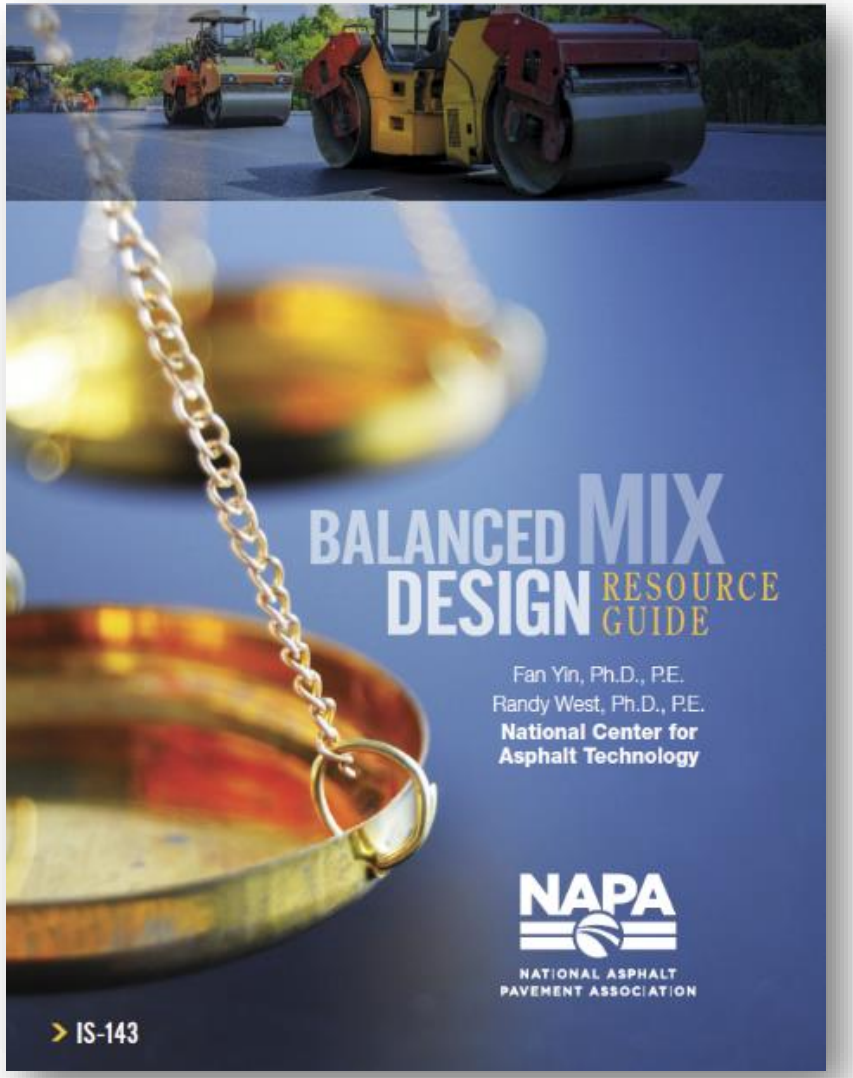
Definitions

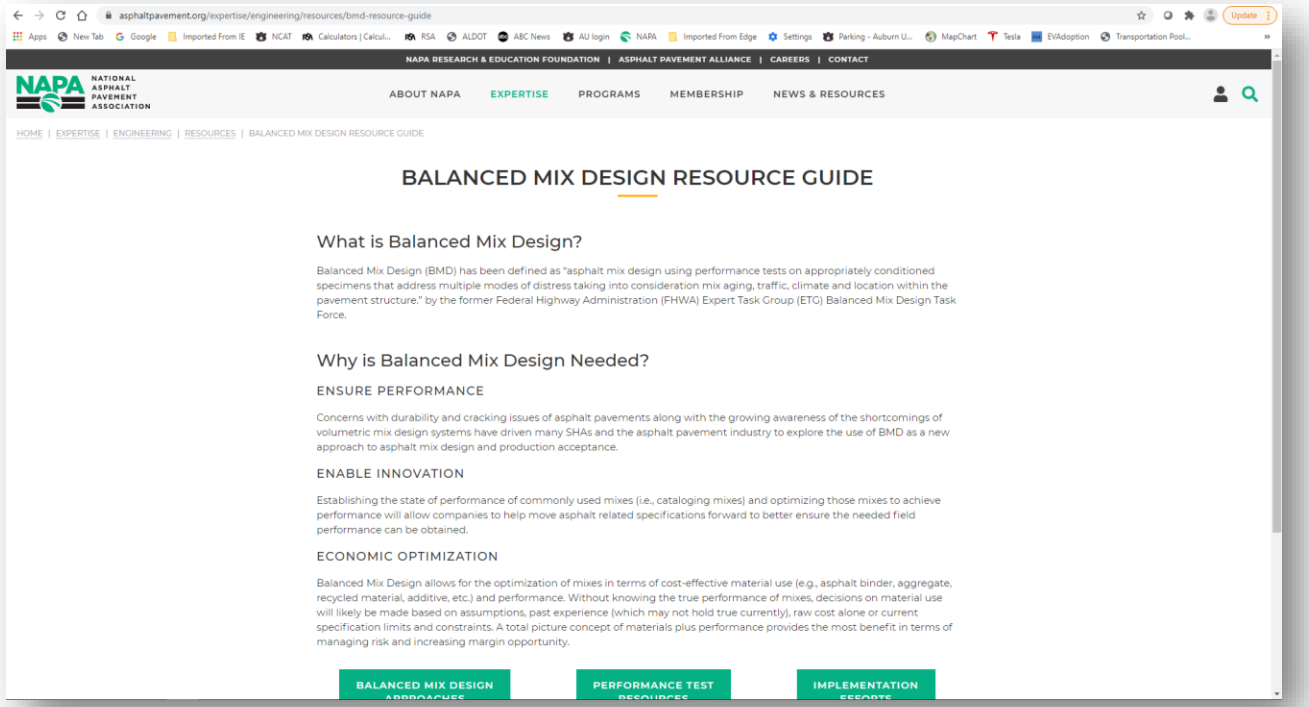
- Pilot Project – a project on which the mixture is produced and accepted based in new AQCs
  - The project is let as a Pilot Project so that contractors can account for some uncertainty in their bids
  - Some DOTs have allowed for new equipment to be purchased as a bid item on Pilot Projects.

The Goals of Pilot Projects

1. Evaluate the preliminary specification and QA program under actual project conditions
   a. Are the testing frequencies reasonable?
   b. Are the proposed acceptance criteria appropriate?
   c. Are the proposed pay factors appropriate?
   d. Is the dispute resolution process OK?
2. Expand the number of stakeholders involved in BMD projects

Balanced Mix Design Resource Guide





https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide

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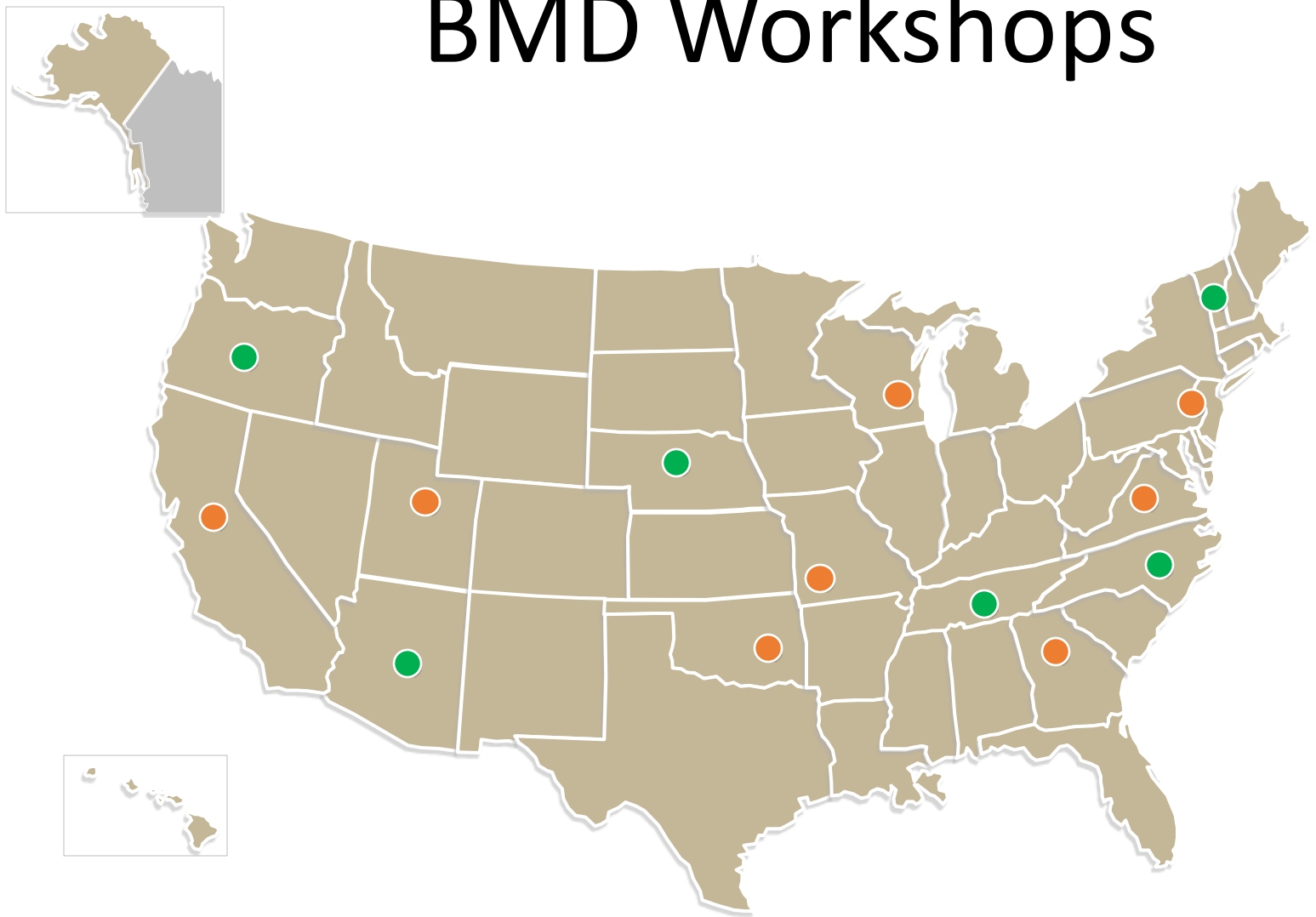
BMD Workshops



- 2019 – in-person
- 2020 - virtual

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Summary

- BMD has made significant progress in the last few years
- It is a good time to start discussing BMD in Michigan
- Simple performance tests with good correlations to field performance have been identified
- Performance tests should be used in QA as well as mix design
- Check out the BMD Resource Guide

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Thank You

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