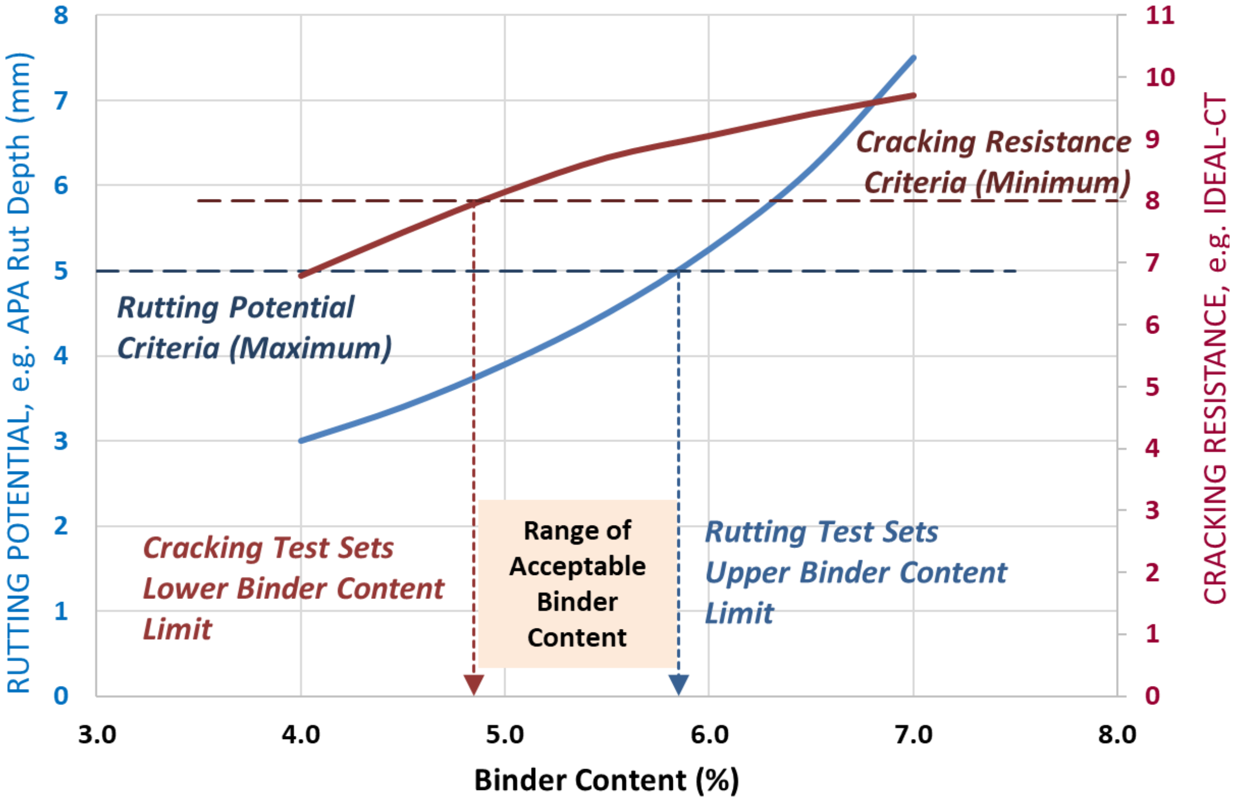
Balanced Mix Design: Comparing Texas, Arkansas, and Oklahoma



(Balancing cracking and rutting)

October 17, 2023

Oklahoma Transportation Research Day

Oklahoma City, OK

Dr. Andrew Braham, Professor

University of Arkansas

OKLAHOMA TRANSPORTATION RESEARCH DAY
"Transportation Excellence through Research and Implementation"

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Overview

- What is balanced mix design?
  - Definition
  - Rutting and durability tests
  - NAPA resource guide
- Experiences in south-central US
  - Texas
  - Arkansas
  - Oklahoma

An asphalt mixture plant in NWA

What is in asphalt mixtures?

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What is Balanced Mix Design (BMD)?

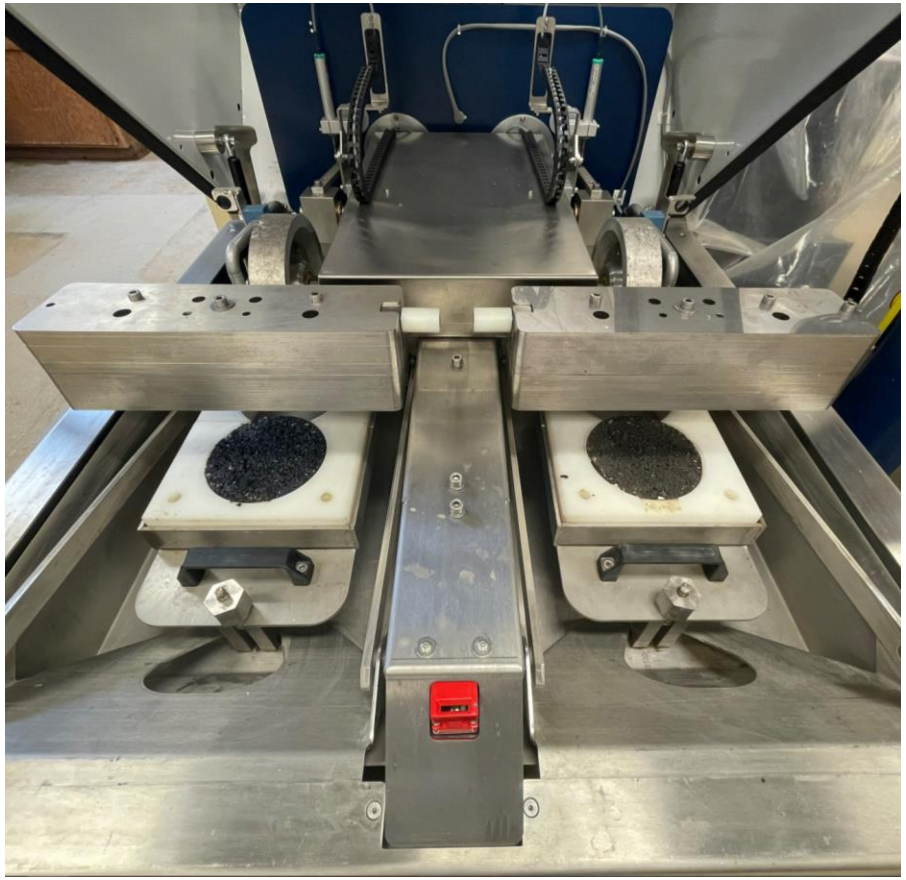
- What happened in the 80's? SHRP
  - Compaction: gyratory compactor
  - Mixture performance tests: moisture sensitivity (indirect tensile test, ITS), rutting (shear test device), cracking (indirect tensile test, IDT)
  - Binder performance tests: dynamic shear rheometer, bending beam rheometer, direct tension tester
- The pendulum
  - SHRP led to cracking
  - But rutting still on the mind
  - How to balance rutting vs. cracking?
- Performance: rutting vs. durability (cracking, moisture, abrasion loss)

Shear Test Device
(Pavement Interactive)

What are the rutting options?

Potential rutting tests

- Asphalt Pavement Analyzer (APA)
  - AASHTO T 340
- Hamburg Wheel Tracking (HWTT)
  - AASHTO T 324
- Flow Number (FN)
  - AASHTO T 378
- Hveem Stability Test
  - AASTHO T 246
- Other potential tests
  - Superpave Shear Test (SST): AASHTO T 320
  - IDEAL-RT: ASTM D8360

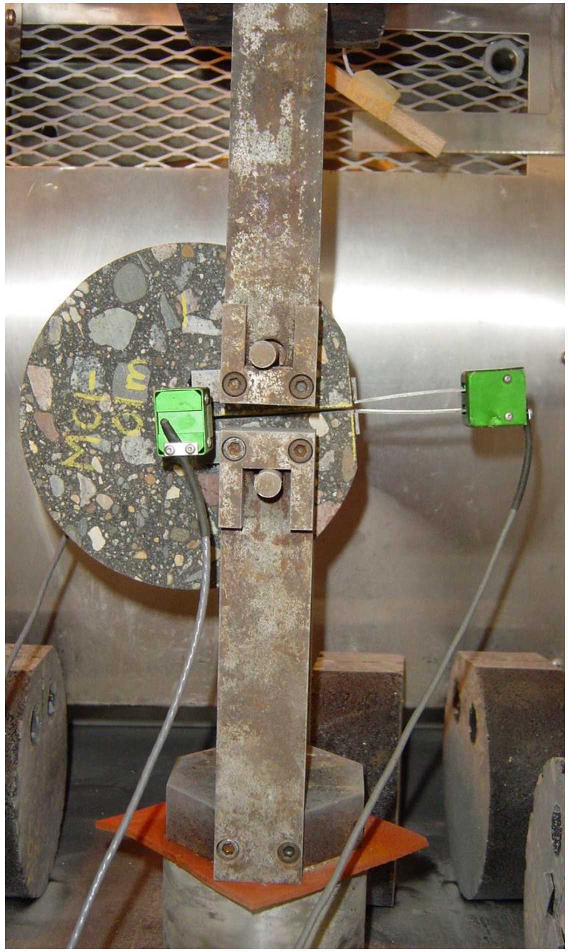


Testing a sample (HWTT, photo from T. Ansari)

What are the cracking options?

Potential cracking tests

- Low temperature/reflective cracking
  - BBR mixture testing: AASHTO TP 125
  - Disc-shaped compact tension [DC(T)]: ASTM D 7313
  - Indirect Tensile Creep Compliance/Strength: AASHTO T 322
  - Semi-circular bend (low temp): AASHTO T 394
- Fatigue
  - Direct tension cyclic fatigue: AASHTO TP 107
  - Flexural bending beam fatigue: AASHTO T 321
- Intermediate temperature
  - Illinois Flexibility Index: AASHTO T 393
  - IDEAL-CT: ASTM D8225
  - Semi-circular bend (inter. temp): ASTM D8044
- Other tests
  - Uniaxial thermal stress and strain: ASTM WK60626
  - Overlay test: Tex-248-F
  - Indirect tensile energy ratio
  - Indirect tensile fracture energy



[DC(T)]

Other durability tests: moisture and/or abrasion

Potential moisture damage and abrasion tests

- Moisture
  - HWTT: AASHTO T 324
  - Indirect Tensile Strength (ITS): AASHTO T 283
  - Moisture Induced Stress Tester (MIST): ASTM D7870
- Abrasion
  - Abrasion loss (Cantabro): AASHTO TP 108

See AASHTO MP 46 – includes summary of state highway agencies

MIST (hmalabsupply.com)

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NAPA Balanced Mix Design Resource Guide

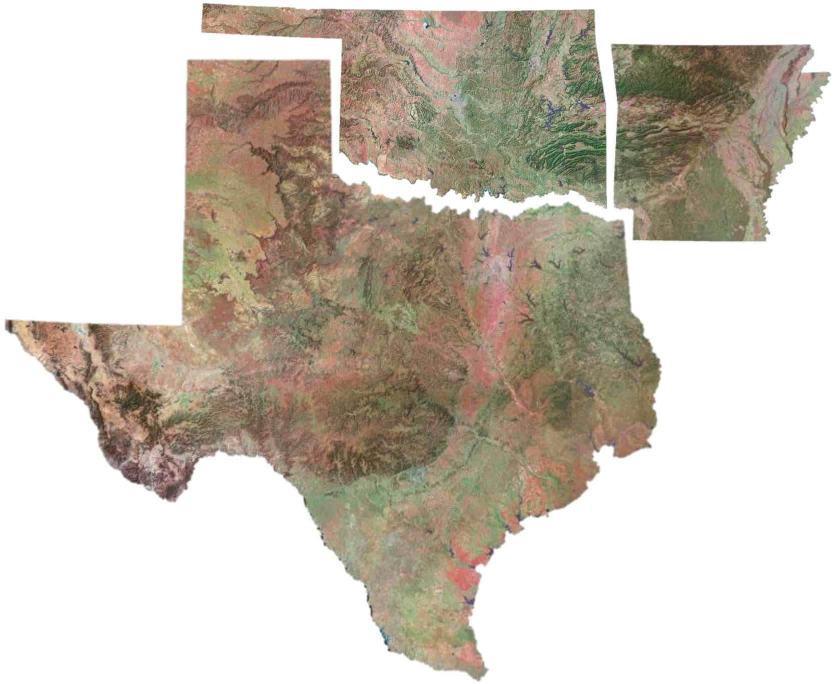
- IS-143
  - Executed by NCAT, 2021
- Four approaches (with case study summaries)
  - Approach A: Volumetric design, performance verification: IL, LA, NJ, TX, VA, VT
  - Approach B: Volumetric design, performance optimization: no states
  - Approach C: Performance-modified volumetric design: CA, MO, OK
  - Approach D: Performance design: AL, TN, VA
- Multiple guidance sections
  - Selecting mixture performance tests
  - Establishing test criteria
  - Modify existing mix designs

NATIONAL ASPHALT PAVEMENT ASSOCIATION

National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

Shifting gears

BMD overview



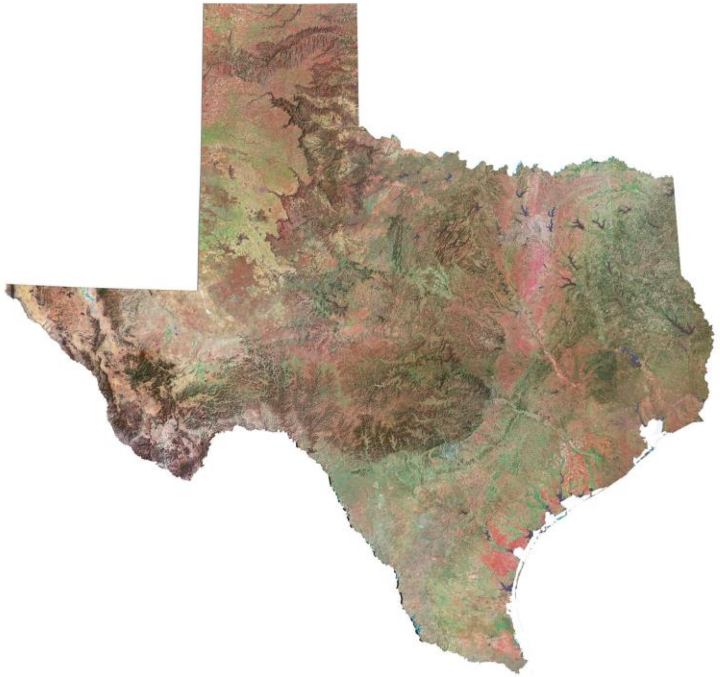
Three specific state examples:
TX, AR, OK

(image from
classicdriver.com)

University of Arkansas

Texas DOT (TxDOT)

- Special Specification 3074: Superpave Mixtures – Balanced Mix Design
  – Search: TxDOT Special Specification 3074
- Six sections
  1. Description
  2. Materials*
  3. Equipment
  4. Construction*
  5. Measurement
  6. Payment


(gisgeography.com)

Starred sections (*) warrant discussion

TxDOT: materials

- Aggregate
  - Coarse aggregate: surface area classification, deleterious materials, decantation, Micro-Deval, LA Abrasion, magnesium sulfate soundness, crushed face count, 5:1 flat and elongated
  - Fine aggregate: linear shrinkage, sand equivalent
- Binder: any PG grade with $\Delta T_C > -6.0°C$
- All allowed: mineral filler, baghouse fines, RAP, RAS, antistripping agent, compaction aid, rejuvenators
- Tack coat: CSS-1H, SS-1H, hot asphalt binder, “specialized” tack coat materials (i.e. reduced tracking tack)

Nothing out of the ordinary

TxDOT: construction

- Various testing requirements
  - Aggregate/recycled material testing
  - Asphalt binder, tack coat sampling
  - Mix design and verification
  - Production and placement testing
- Mix design
  - Two gradation bands
  - 35-50 gyrations
  - Dry IDT: 85-200 psi
  - Boil test
  - Hamburg wheel tracking
  - Overlay test

Table 11A (Tex-242-F)
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Minimum # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	10,000[2]
PG 70	15,000[3]
PG 76 or higher	20,000

Table 11B (Tex-248-F)
Overlay Test Requirements

Mixture Property	Surface Mixtures
Critical Fracture Energy (CFE), in.-lb/in.^{2}, Min	1.0
Crack Progression Rate (CPR), Max	0.45

What about placement?

TxDOT: placement acceptance

- In-place air voids
- Segregation
  - Density or
  - Thermal imaging
- Longitudinal joint density
- Ride quality

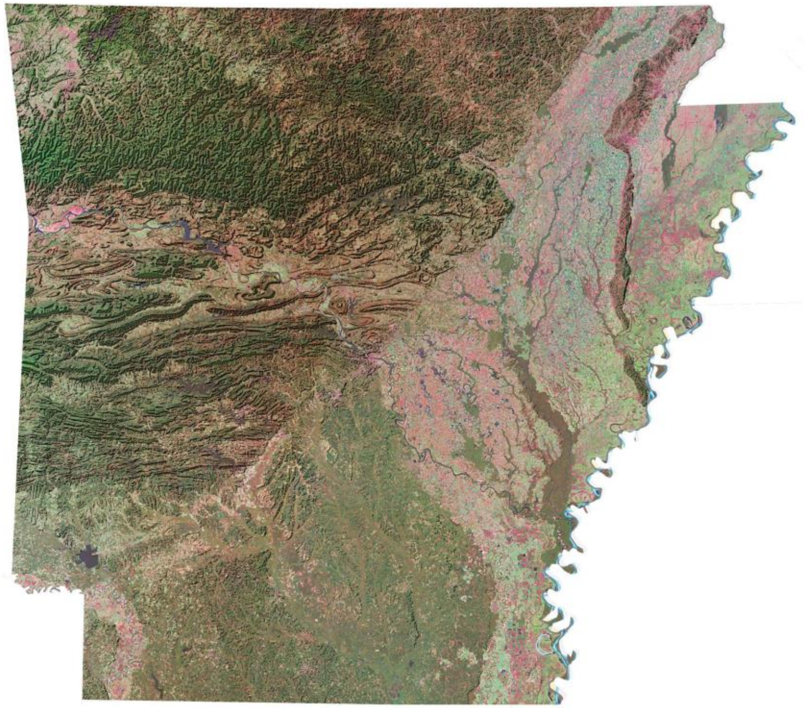
Asphalt being placed in NWA

Search: TxDOT Special Specification 3074

Arkansas DOT

- Research in progress (as of October 2023)
- Hybrid CD approach:
  - Conduct rutting/cracking tests at four P_b, float N_{des}
  - Select optimal binder content
  - Run moisture damage tests
  - Measure required volumetric properties
  - Establish job mix formula for production
- Experimental matrix

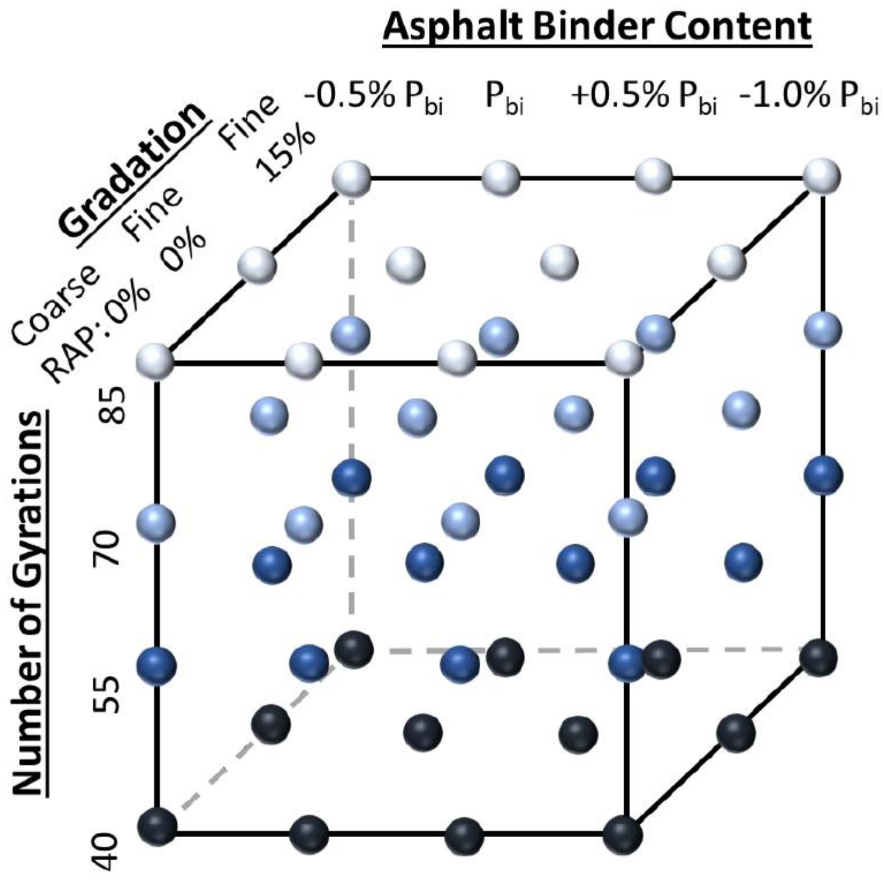
Three aggregate gradations	Four gyration levels	Four asphalt binder levels
Fine: 0% RAP	40	-0.5% P_{bi}
Fine: 15% RAP	55	P_{bi}
Coarse: 0% RAP	70	+0.5% P_{bi}
	85	+1.0% P_{bi}



(gisgeography.com)

ARDOT: Testing

- Rutting tests:
  - APA, Flow number
- Cracking tests:
  - IDEAL-CT, I-FIT
- Other tests:
  - Compaction metrics, TSR, Dynamic Modulus, S-VECD, HWTT
- 2023: five projects placed (or will be placed) in the field
  - North, northeast, central, southeast



Please check back in 2024!

Oklahoma

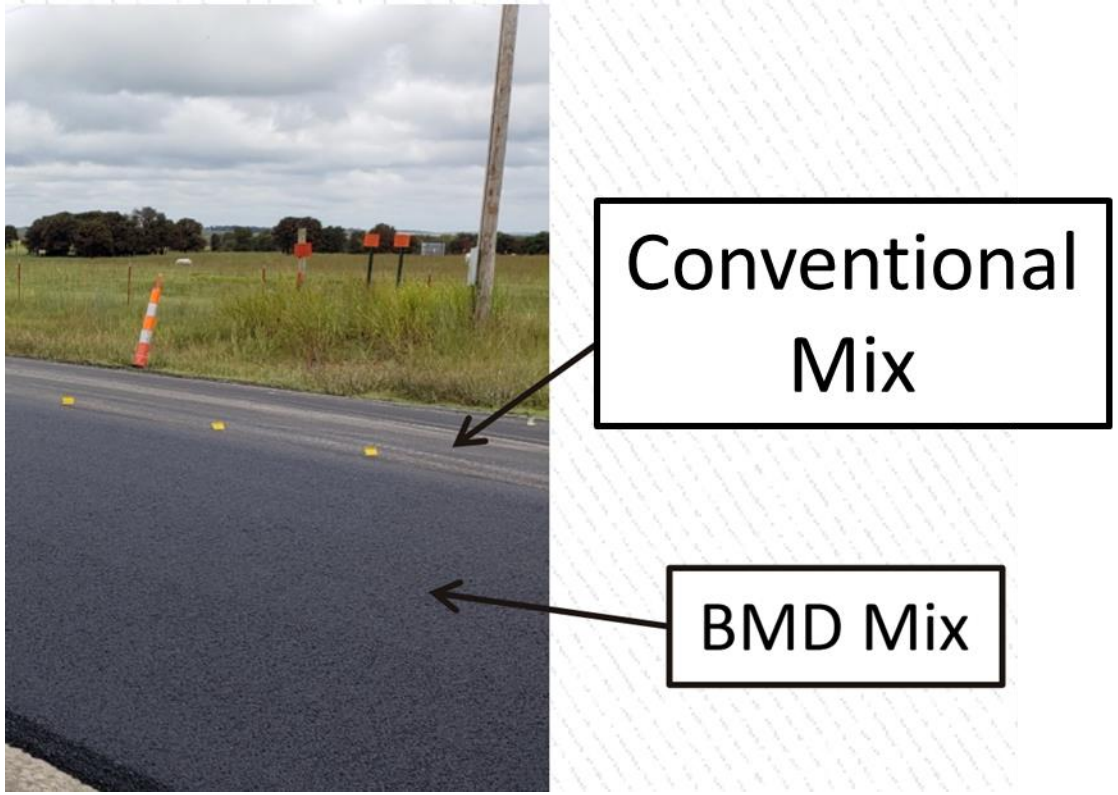
- Objectives of pavement
  - Reduce cracking potential
  - Extend life
  - Sustainable and cost effective
  - Simply design process
  - Allow use of new/innovative technologies
- BMD performance tests
  - HWTT for rutting
  - IDEAL-CT) for cracking (CT_{index}≥100 surface, ≥60 intermediate)

(gisgeography.com)

Four phase approach for implementation

Implementation

- Phase 1: evaluation
  - 2018: literature review, equipment, test selection, shadow projects (4)
- Phase 2: proof of concept
  - 2022: initial special provision, identify challenges, pilot projects (11)
- Phase 3: long-term evaluation
  - 2023: benchmarking, field study, aging protocols, pilot projects (4)
- Phase 4: implementation
  - 2024: partnerships, field QC/QA, implementation projects (>8)



From Suitor and Vivanco, ODOT

Let's take a look at the special provisions

Special provisions

- Performance tests: IDEAL-CT and HWTT
- Short term age prior to compaction, 4 h ± 5 min
  - 240 ± 10°F for WMA
  - 275 ± 10°F for HMA
- May contain RAP
  - Intermediate course (≤20%) up to 30% with soft binder
  - Surface course (≤15%) up to 25% with soft binder
- N_{des} 96-97% G_{mm}
- Design according to AASHTO MP 46 – Approach B
  - Volumetric design, performance optimization
- Pay adjustment factors modified for density/air voids

Testing a sample (IDEAL-CT, photo from T. Ansari)

Thank you to David Vivanco for help with ODOT info

Conclusions

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  - NAPA resource guide
- Experiences in south-central US
  - Texas
  - Arkansas
  - Oklahoma

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Questions?

Thank you!

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