MATC
MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

North Dakota *Asphalt Conference* March 2, 2022

FHWA MOBILE ASPHALT TECHNOLOGY CENTER VISIT TO NORTH DAKOTA US-83 Project

Leslie Myers, Ph.D., PE
FHWA Office of Preconstruction, Construction and Pavements

FHWA is the source for all images in this presentation, unless otherwise noted

FHWA Disclaimers

- Contents of this presentation do not have the force and effect of law and are not meant to bind the public in any way.
  - This presentation is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.
  - Compliance with applicable statutes or regulations cited in this document is required.
- All AASHTO and ASTM standards mentioned in this workshop content are non-governmental, voluntary standards and are not required under Federal law.
- The approaches and methods discussed in the presentations are not Federal requirements unless otherwise stated. Some items may be required by State policy or specification.
- Unless otherwise noted, FHWA is the source of all images in this presentation.
- The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this presentation only because they are considered essential to the objective of the presentation. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

Acronyms

- 3D: Three Dimensional
- ABML-ID: FHWA Asphalt Binder and Mixture Laboratory – Implementation Division
- ABT: Asphalt Binder Tester
- AC: Asphalt Content
- AI: Artificial Intelligence
- AIMS: Aggregate Imaging System
- ALF: FHWA Accelerated Loading Facility
- AMPT: Asphalt Mixture Performance Tester
- BMD: Balanced Mix Design
- DPS: Dielectric Profiling System
- DOT: Department of Transportation
- E*: Dynamic Modulus of Asphalt Mix
- FAA: Fine Aggregate Angularity
- FHWA: Federal Highway Administration
- FTIR: Fourier Transform Infrared Spectroscopy
- G_f: Fracture Energy
- G_{mb}: Bulk Specific Gravity
- G_{mm}: Maximum Specific Gravity
- GPS: Global Positioning System
- HWTT: Hamburg Wheel Tracking Test
- IDEAL-CT: Ideal Test for Cracking
- IDEAL-RT: Ideal Test for Rutting
- I-FiT: Illinois Fatigue Test
- JMF: Job Mix Formula
- LPL: Lower Production Limit
- LTS: Laser Texture Scanner
- MATC: Mobile Asphalt Technology Center
- MPD: Mean Profile Depth
- ND: North Dakota
- NRRI: Normalized Rutting Resistance Index
- PG: Penetration Grade
- QA: Quality Assurance
- RAP: Reclaimed Asphalt Pavement
- RAS: Recycled Asphalt Shingles
- REOB: Recycled Engine Oil Bottom
- T_f: Shear Strength
- UPL: Upper Production Limit
- VFA: Voids in Fine Aggregate
- VMA: Voids in Mineral Aggregate
- VTM: Total Voids in the Mix
- XRF: X-Ray Florescence

On Deck: FHWA Performance Data, Hwy 83 Review

FHWA Mobile Asphalt Technology Center (MATC)

- Program Goals
- Site Visit to North Dakota
- Mixture information
- Volumetric testing

Mixture Performance Testing: In the lab

- Cracking tests
- Rutting tests & moisture susceptibility
- Ignition oven testing of reclaimed asphalt pavement (RAP)

Mixture Performance Testing: In the field

- Pulse induction testing for in situ surface layer thickness
- Macrotexture of asphalt surface by 2 methods

Summary

- Closing observations
- Asphalt performance research at FHWA Turner-Fairbank Highway Research Center

FHWA Mobile Asphalt Technology Center (MATC)

MATC
MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

Program Goal & Focus Areas

MATC

Innovative technologies and practices are implemented by agencies and industry to provide durable, safe, and sustainable asphalt pavements on our nation's highways.

- On-site field evaluations & training + 2-day QA workshop
- Asphalt materials & field testing
- Post-construction evaluation
- Innovation implementation
- Equipment loans
- Hands-on and virtual demos
- Specification review
- Asphalt Binder and Mixture Laboratory-Implementation Division (ABML-ID)

MATC MOBILE ASPHALT TECHNOLOGY CENTER
U.S. Department of Transportation
Federal Highway Administration

Technologies Offered by FHWA MATC

MATC

Mixture

- AMPT suite of tests (cyclic fatigue, E*)
- Overlay test for reflective cracking
- Flexibility index test (I-FIT) for fracture resistance
- ITC (IDEAL-CT) for crack resistance
- IDEAL-RT for rutting resistance
- Hamburg wheel tracker

Materials

- X-Ray Fluorescence (XRF) Spectrometer
- ABT (true grade binder)
- FTIR for binder molecular analysis

Field

- Paver-mounted thermal profiler (PMTP)
- Pulse induction technology for in-place pavement thickness
- Pavement macrotexture measurements (3 methods)
- Dielectric profiling systems (DPS)

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

Site Visit to North Dakota

Site Visit

- **ND DOT Goals for Project**
  - Compare performance of 2 typical ND DOT surface asphalt mixtures
  - Demonstration of balanced mix design on ND mixes
  - Side-by-side (NDDOT & FHWA) testing of ignition furnace testing of reclaimed asphalt pavement (RAP) samples
  - Advanced testing to show properties of various ND local aggregates
  - Material Inputs for AASHTO Pavement ME Design demonstration of US-83
- **Post-Construction Evaluation**
  - Side-by-side (NDDOT & FHWA) testing of mat uniformity
  - Pavement surface characteristics (macrotexture) for improved safety

MATC Visit: US-83 near Maxbass, ND

September 12th – October 7th, 2021

Site Visit

- **Purpose of visit:** demonstrate various laboratory and field technologies for asphalt mix design and construction
- Focus on BMD performance testing indices for standard NDDOT surface mixtures
- Comparison between two dense-graded asphalt surface mixtures with differing traffic classifications; US-83 (FAA 45) and ND-28 (FAA 43)

Source: FHWA

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

MATC Visit: US-83 near Maxbass, ND

September 12th – October 7th, 2021

Site Visit

- US-83: paving from Renville, ND north approx. 16 miles
- 12.5mm NMAS, FAA-45, Dense-Graded Asphalt surface mixture with PG 58H-28 and 10% RAP
- MATC at the project site from 9/12/21 to 10/7/21
- Data on samples and field testing from 9/22/21 to 9/24/21 production and paving

Source: FHWA

US-83: 12.5mm NMAS, FAA-45 Dense-Graded Asphalt Surface

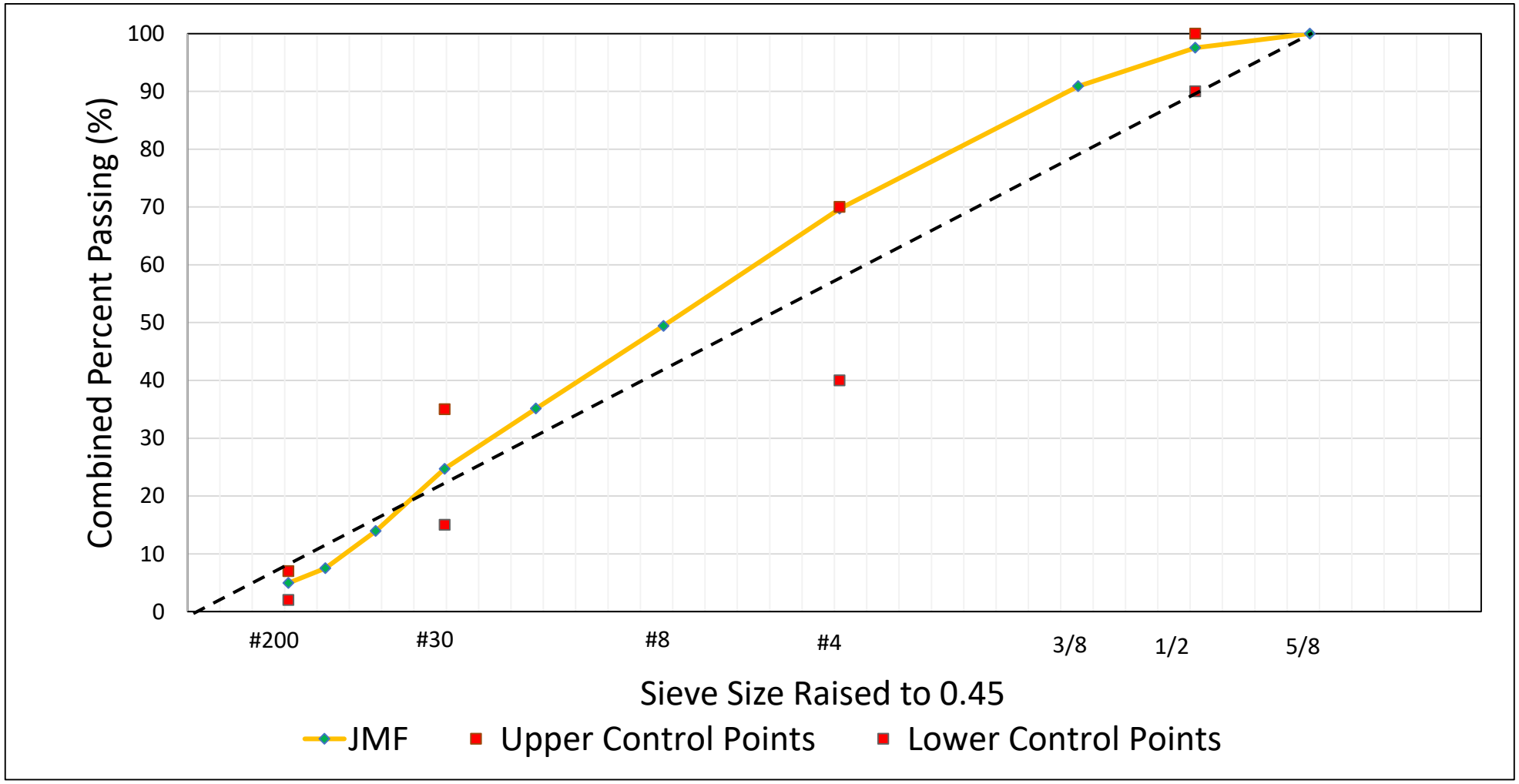
Mix Info

- Aggregates: Helgeson Rock, Helgeson Crusher Dust, Helgeson Washed Dust, TNT Chips, TNT Sand
- 10% Recycled Asphalt Pavement
- Asphalt Binder: PG 58H-28
- JMF Design
  - Asphalt Content – Target 5.0%
  - Air Voids – 4.0%
  - VMA – 14.2%
  - VFA – 71.9%
  - FAA – 45.4%
  - AC Film Thickness: 7.8

Source: FHWA

JMF Gradation – US-83 Mixture

Mix Info



Source: FHWA

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

MATC Testing Plan

MATC Demo Test Plan

Mixture Testing			Field Testing	Aggregate Testing	Pavement Design Example Testing
Volumetric Tests	**Rutting Performance Tests**	**Cracking Performance Tests**			
Asphalt Content by Ignition (%)	IDEAL Rutting Test (RT_{Index})	IDEAL Cracking Test (CT_{Index})	Laser Texture Scanner (MPD)	Aggregate Imaging Measurement System (AIMS)	Dynamic Modulus (E*) of mix
Gradation (%Passing)			Sand Patch Test (MPD)		
Maximum Specific Gravity (G_{mm})					
Bulk Specific Gravity (G_{mb})	Hamburg Wheel Tracking Test [a] (HWTT)	Illinois Flexibility Index Test (FI)	Pulse Induction Technology (thickness)	Fine Aggregate Angularity (FAA)	Complex Modulus (G*) of binder
Volumetric Properties VTM (%) VMA (%) VFA (%)			Dielectric Profiling System (DPS)		Phase Angle (δ) of binder

(a) All HWTT conducted at 50°C except for US-83 Sample 3 which was tested at 45°C for comparison purposes.

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation Federal Highway Administration

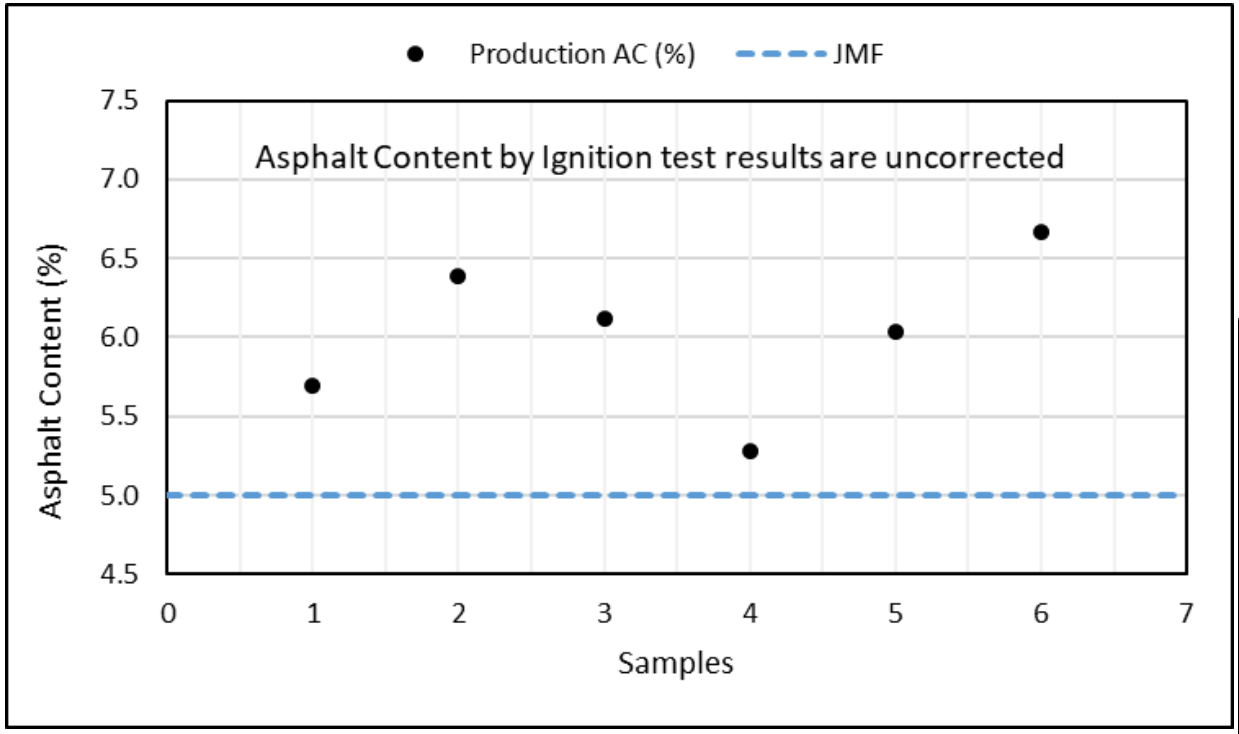
FHWA Lab Test Results

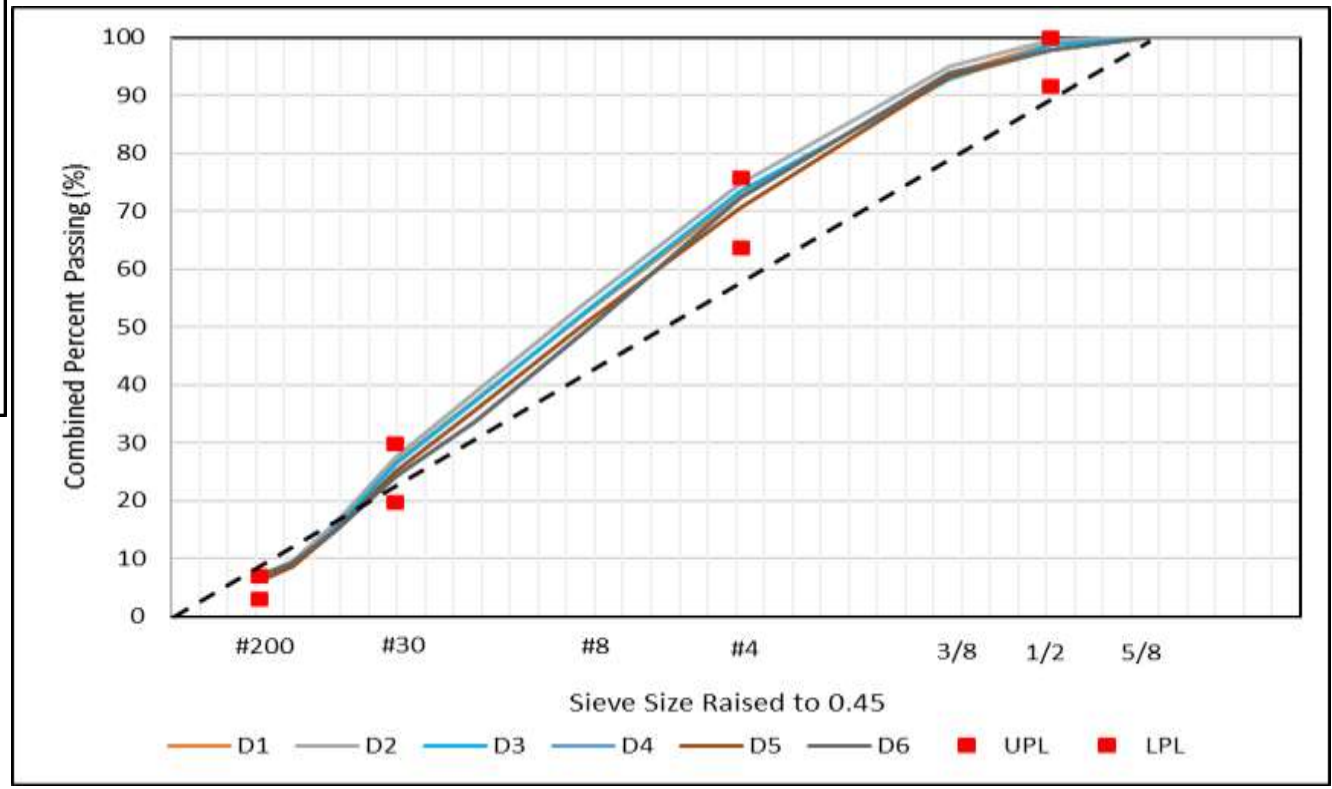
MATC
MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

Asphalt Binder Content & Gradation Control – US-83

Volumetric Testing

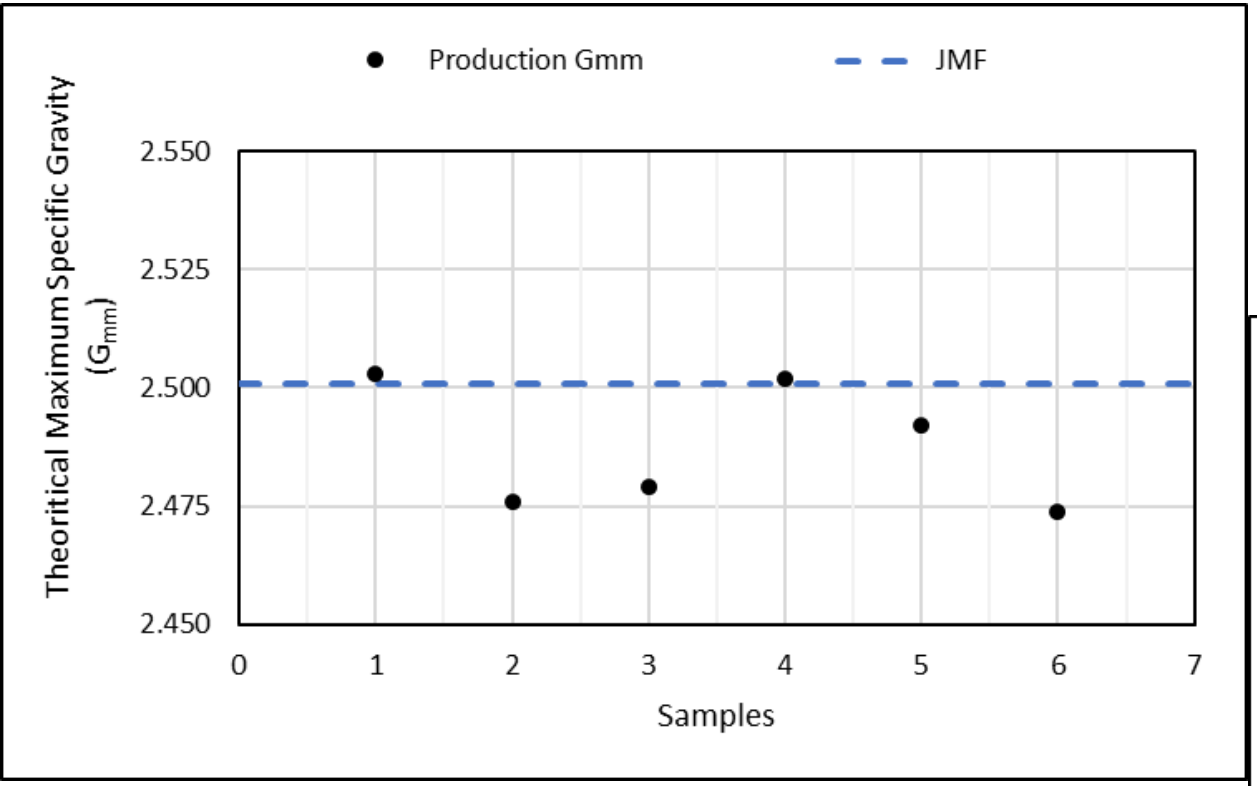


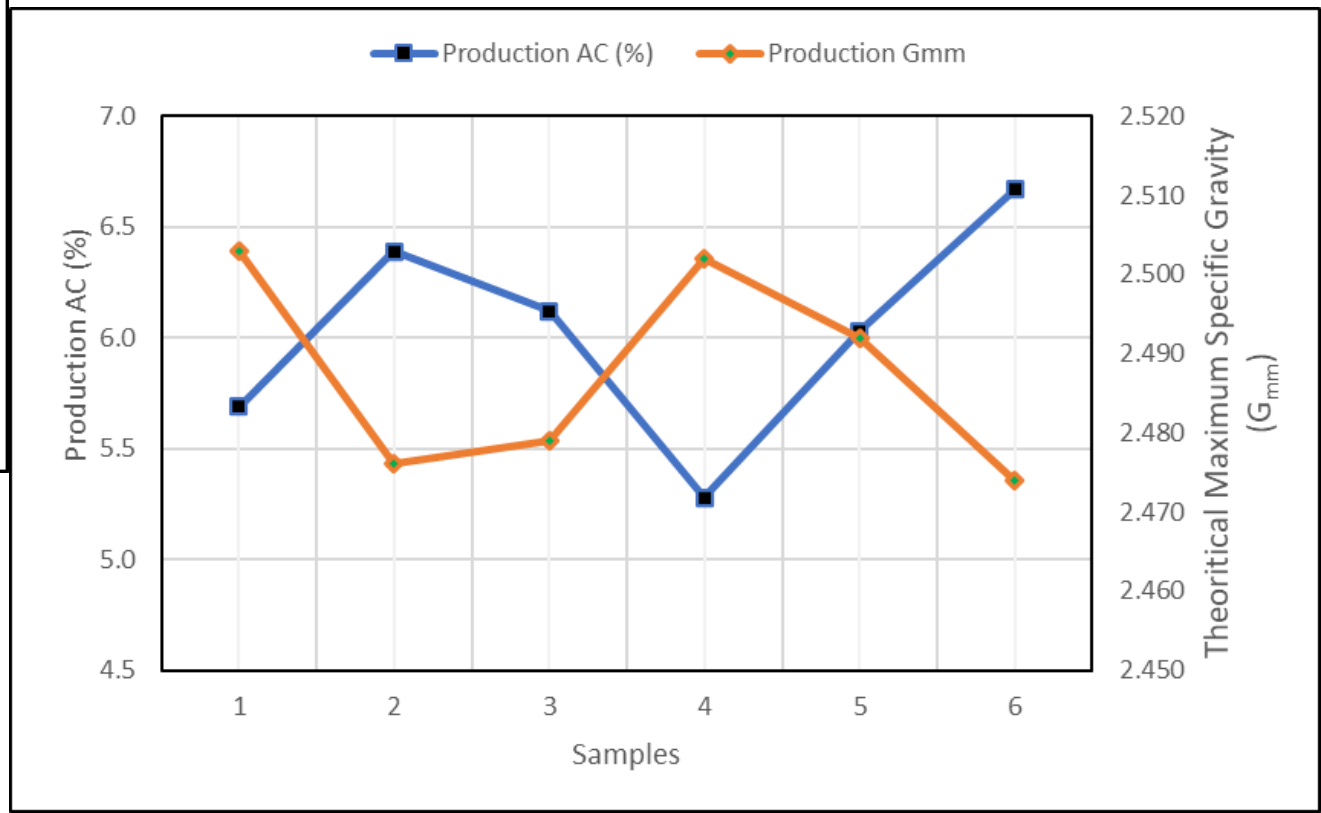


Source: FHWA

Maximum Specific Gravity (G_{mm}) & %AC vs G_{mm} – US-83

Volumetric Testing

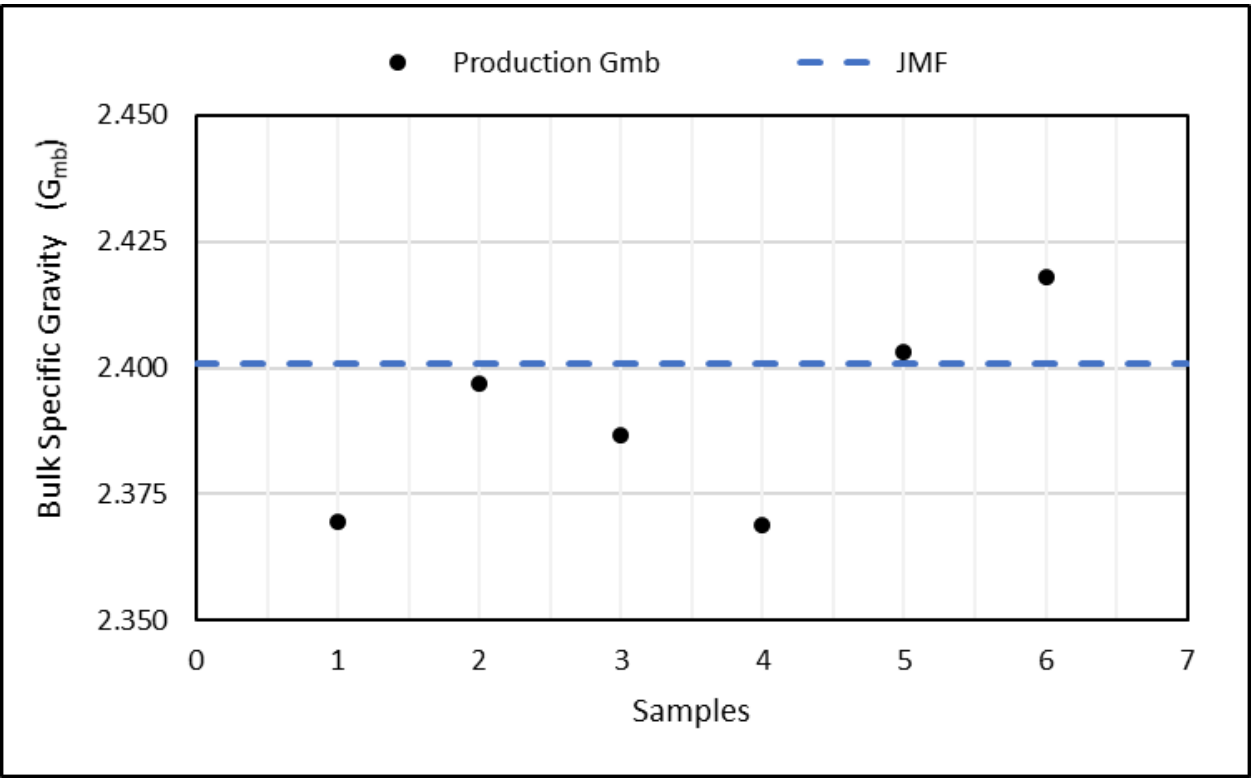




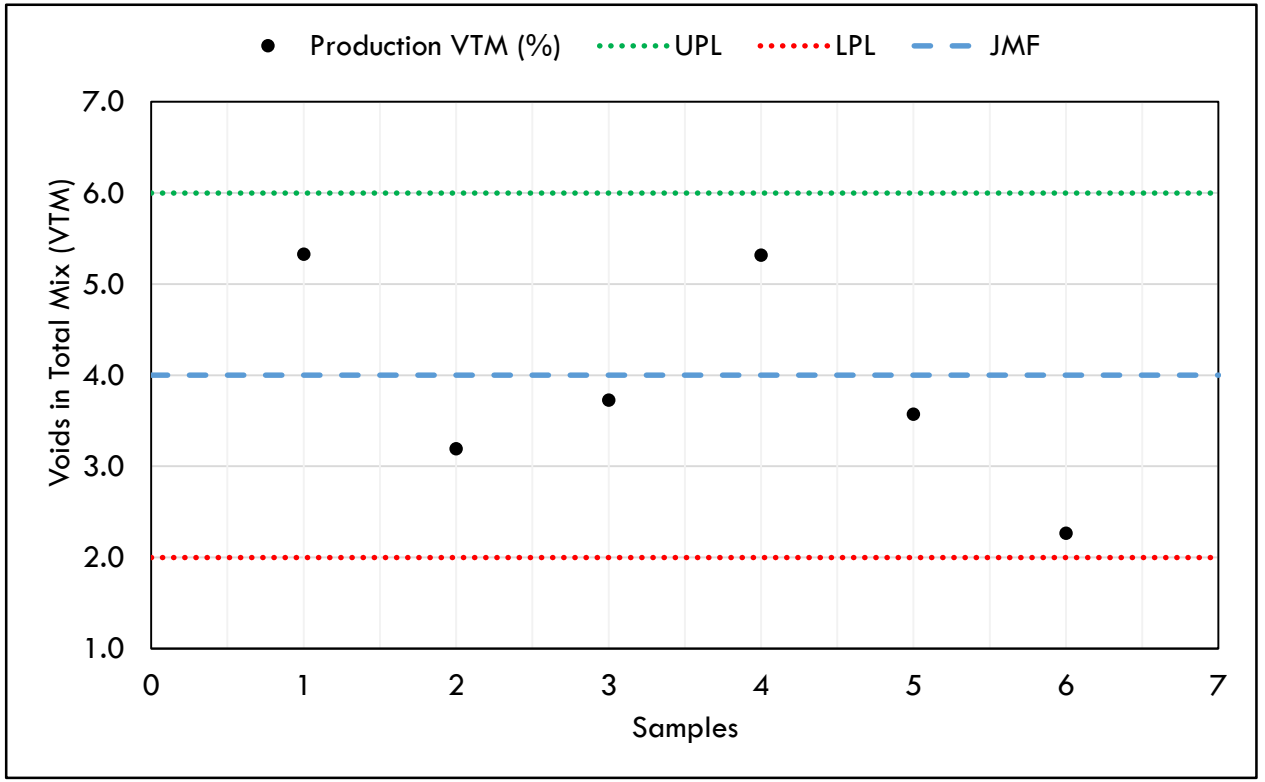
Source: FHWA

Bulk Specific Gravity (G_{mb}) & Voids in Total Mix (VTM) – US-83

Volumetric Testing



Note: results shown are single point tests on individual specimens

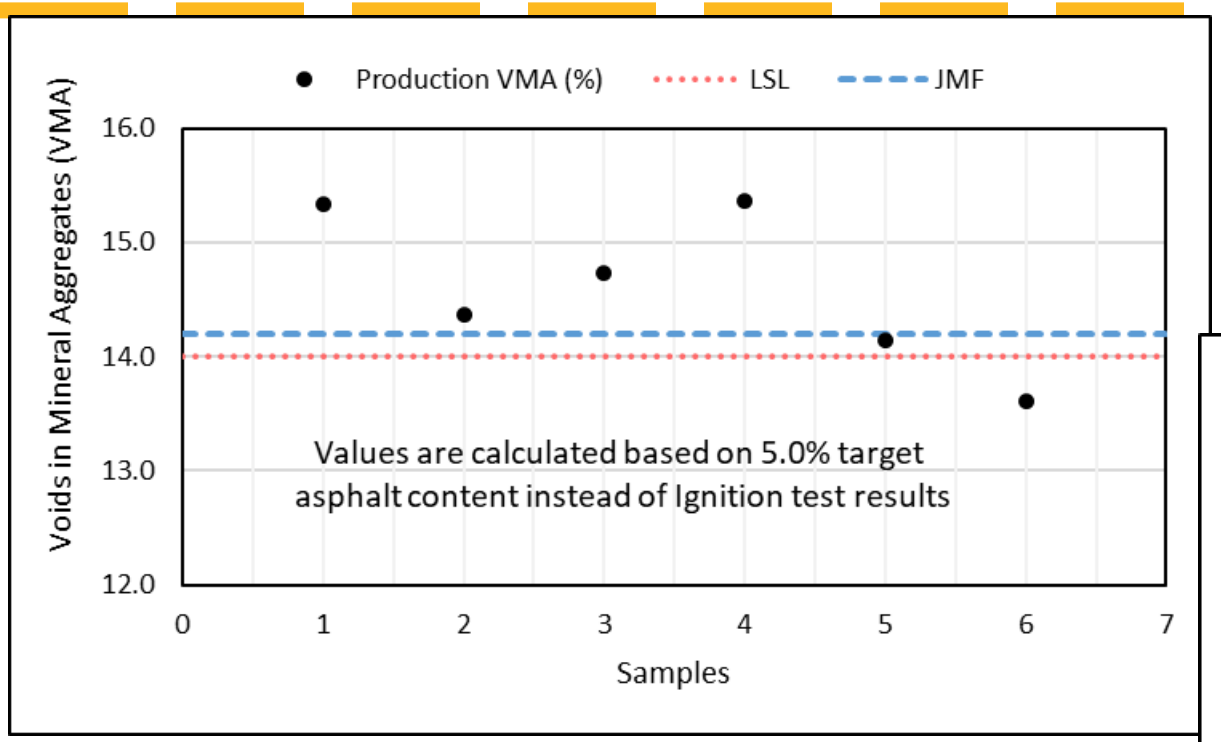


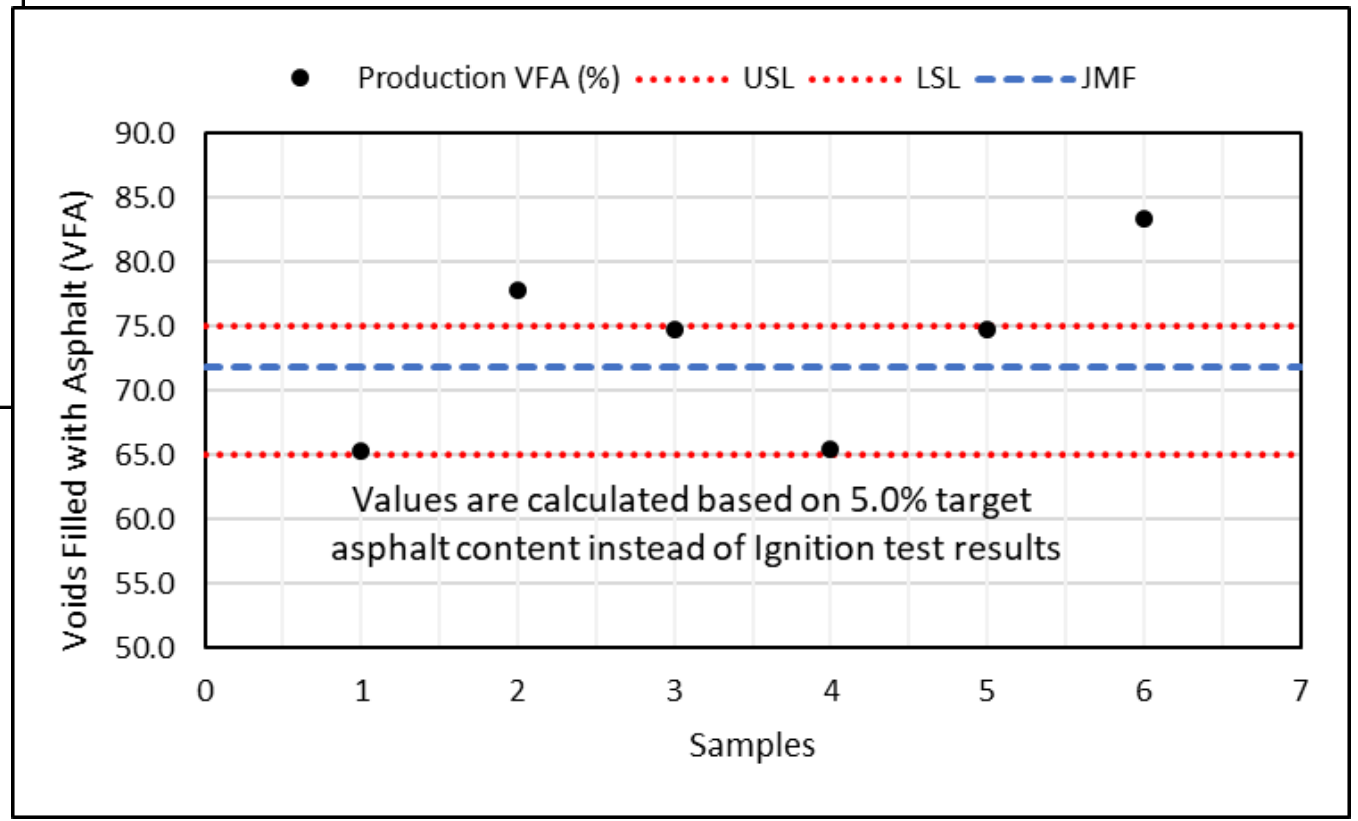
Source: FHWA

MATC MOBILE ASPHALT TECHNOLOGY CENTER
U.S. Department of Transportation Federal Highway Administration

Voids in Mineral Aggregate (VMA) & Voids Filled with Asphalt (VFA) – US-83

Volumetric Testing





Source: FHWA

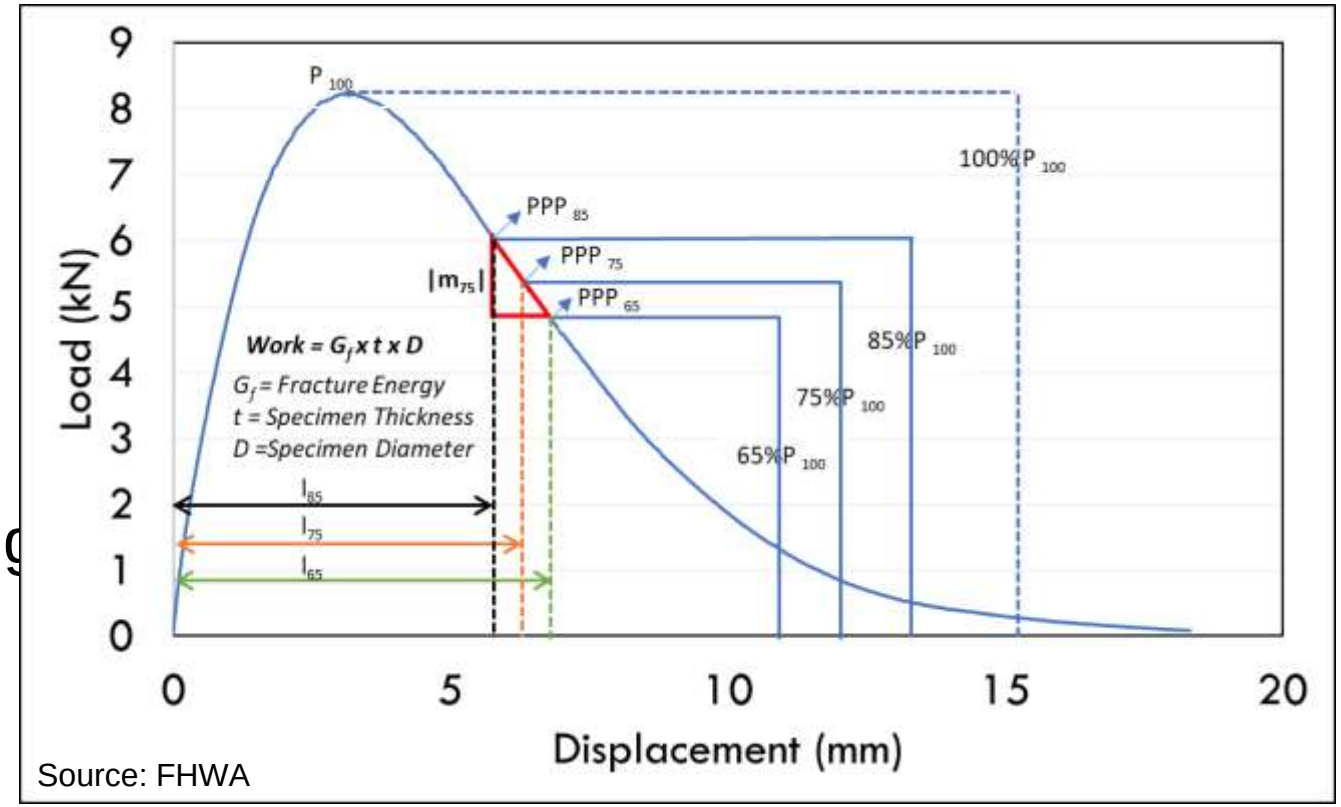
Cracking Performance Tests

Indirect Tension Cracking Test (IDEAL-CT)

BMD Cracking

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

- ASTM D8225-19
  - Characterizes asphalt mixture cracking resistance
- Testing parameters:
  - Temperature = 25°C
  - Contact load = 100 ± 10 N
  - Loading rate = 50 ± 2 mm/min
- Parameters calculated:
  - Fracture energy (G_f)
  - Cracking Test Index (CT_{index})
- Use of cylindrical geometry, no cutting/notching necessary
  - 150 mm diameter with 62 ± 1 mm height
  - Test Duration less than 10 seconds
  - Three replicates



Source: FHWA

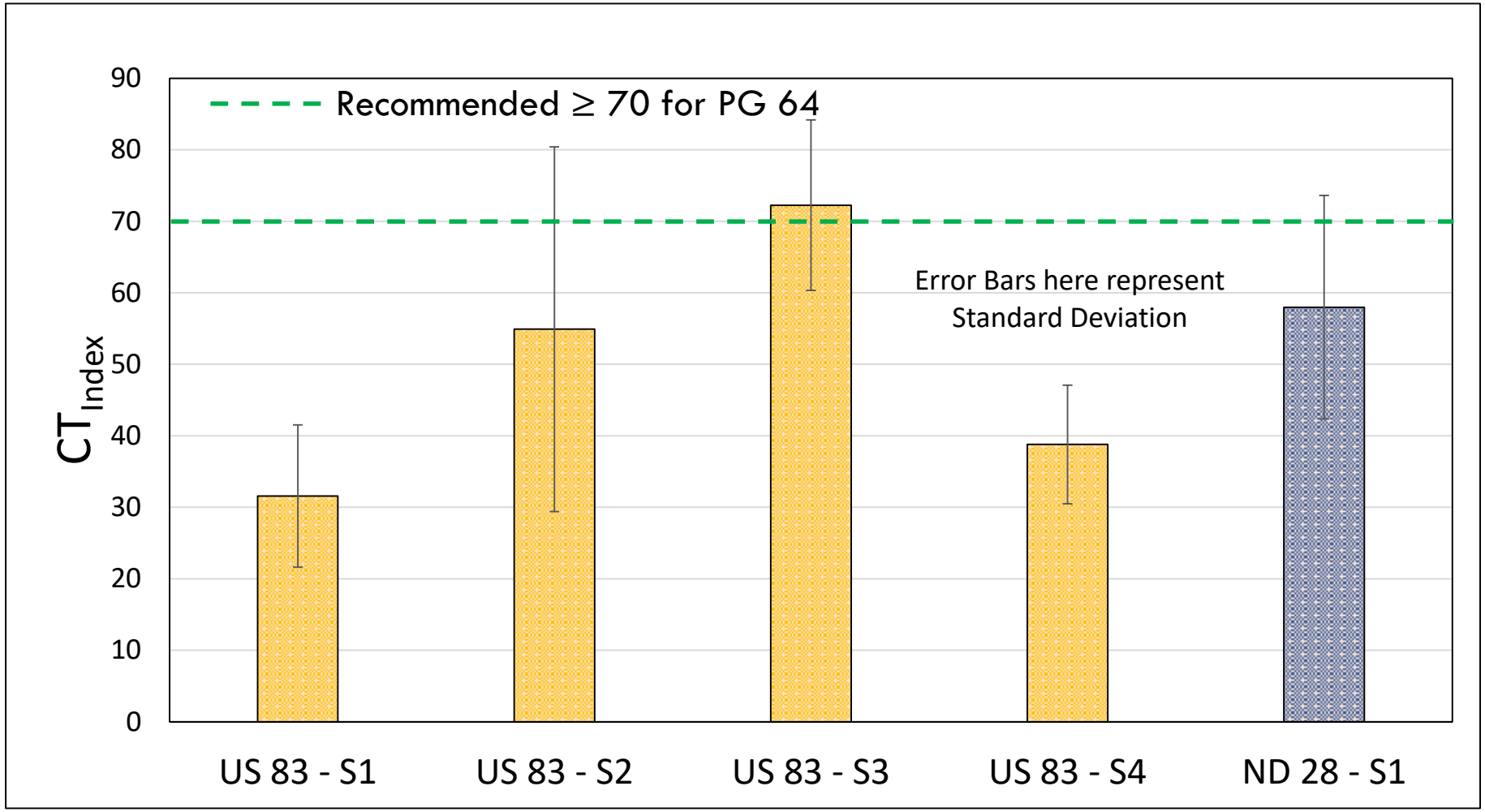
All AASHTO standards mentioned in this workshop are voluntary and are not required under Federal law.

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation Federal Highway Administration

IDEAL-CT (CT_{Index})

BMD Cracking



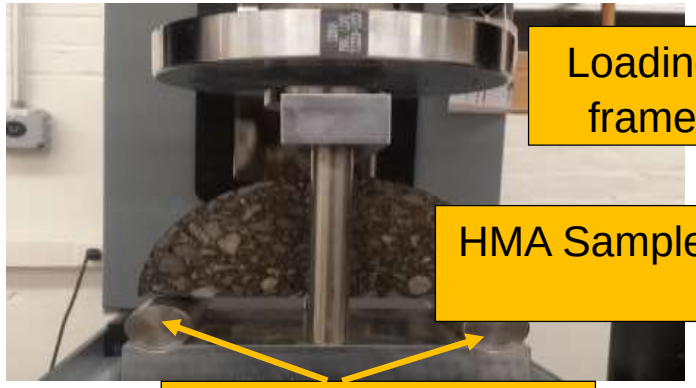
Source: FHWA

Illinois Flexibility Index Test (I-FIT)

BMD Cracking

- AASHTO TP 124-16
  - Characterizes asphalt mixture fracture resistance
- Testing parameters:
  - Temperature = 25°C ± 0.5°C
  - Contact load = 100 ± 10 N
  - Loading rate = 50 mm/min
- Parameters calculated:
  - Fracture energy (G_f)
  - Flexibility Index (FI)
- Use of semi-circular bend (SCB) geometry with notch (15 mm deep and 1.5 mm wide) at the center
  - 150 mm diameter with 50 mm height
  - Test Duration less than 10 seconds
  - Four replicates

Source: FHWA



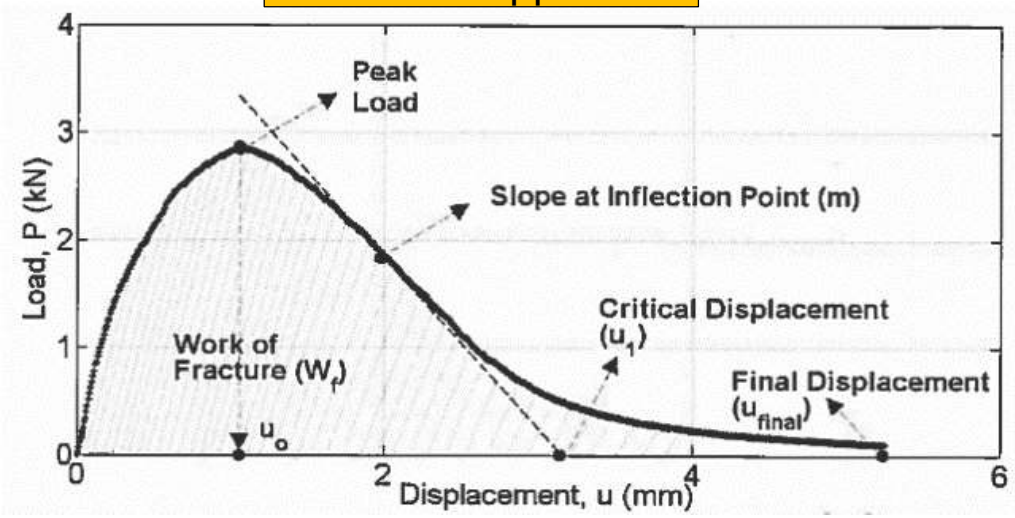


Image: AASHTO TP 124-16

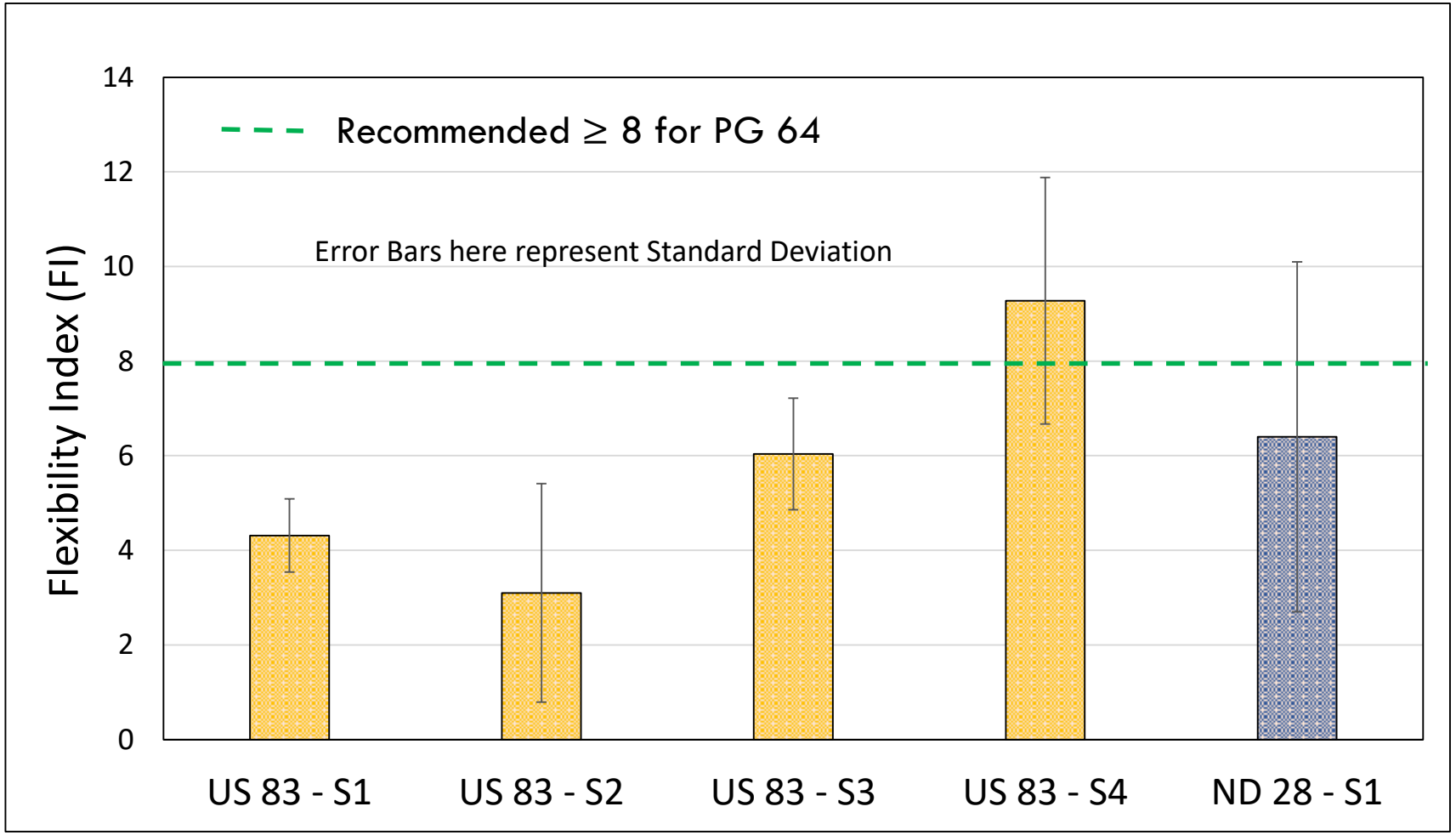
All AASHTO standards mentioned in this workshop content are voluntary and are not required under Federal law.

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation Federal Highway Administration

I-FIT Flexibility Index (FI)

BMD Cracking



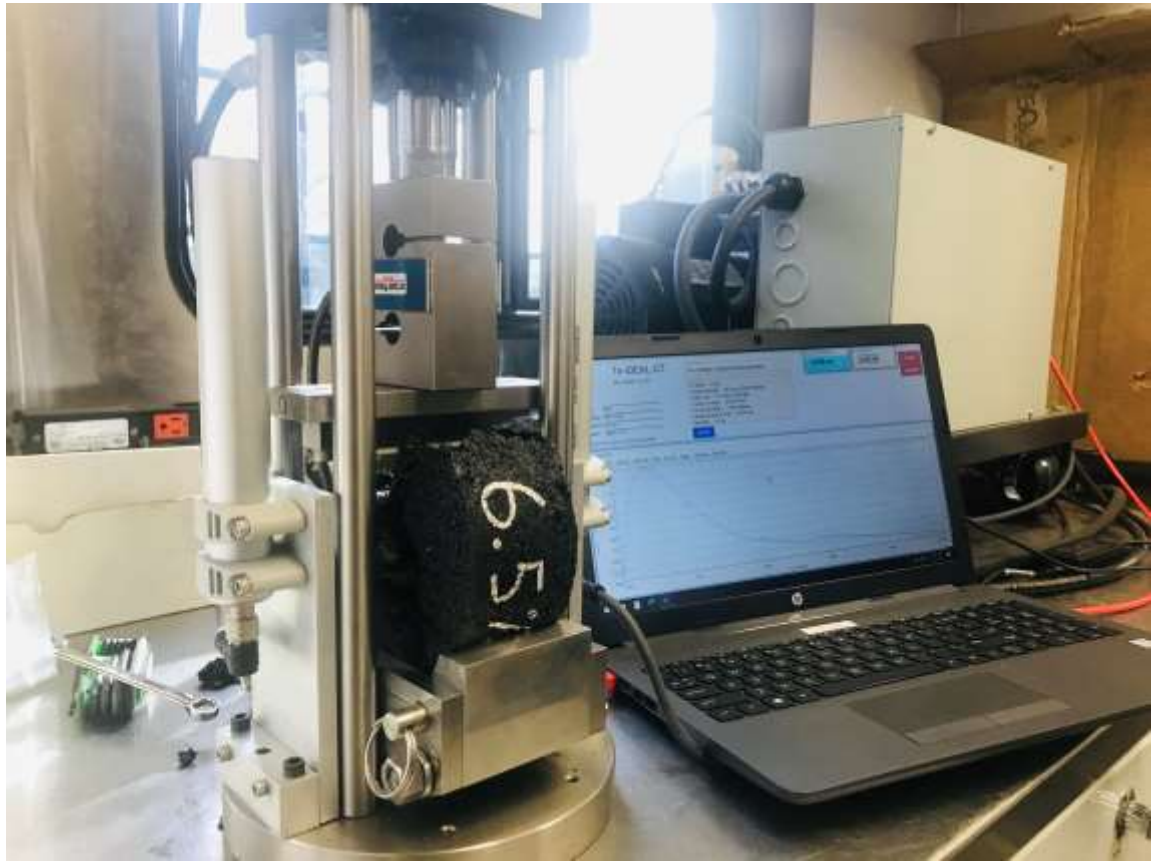
Source: FHWA

Rutting Performance Tests

IDEAL-RT

BMD Rutting

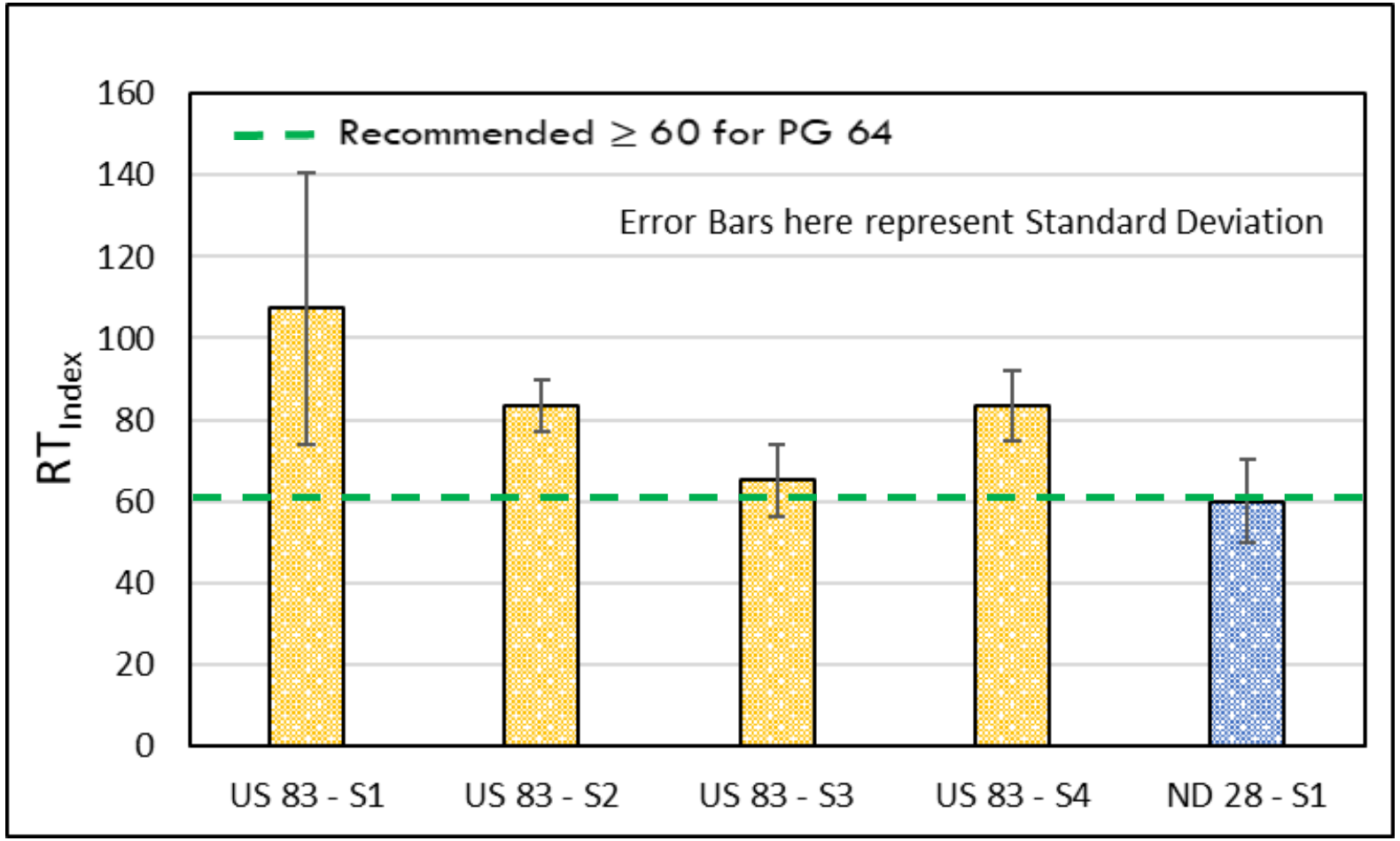
- ASTM WK71466
  - Characterizes asphalt mixture rutting resistance
- Testing parameters:
  - Temperature = Target (35°C - 65°C) ± 1.0°C
  - Loading rate = 50 ± 2 mm/min
- Parameters calculated:
  - Shear strength (T_f)
  - Rutting Test Index (RT_{index})
- Use of cylindrical geometry, no cutting or notching necessary
  - 150 mm diameter with 62 ± 1 mm height
  - Three replicates



Source: FHWA

IDEAL-RT (RT_{Index})

BMD Rutting



Source: FHWA

Recommended RT_{Index} values by TTI

PG Binder	RT_{Index}
PG 64-XX	≥60
PG 70-XX	≥65
PG 76-xx	≥75

Hamburg Wheel Tracking Test (HWTT)

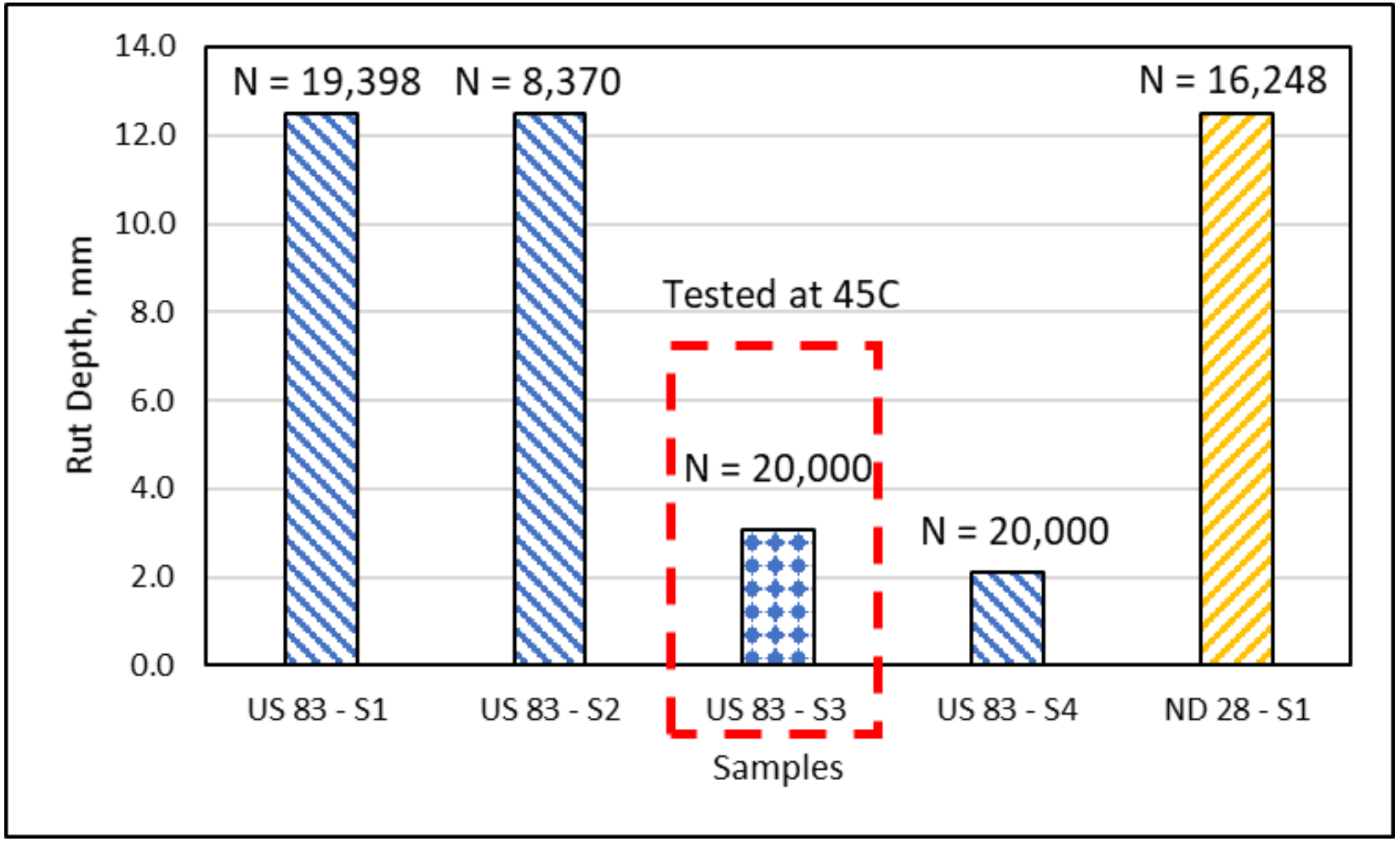
BMD Rutting

- AASHTO T 324
  - Characterizes asphalt mixture rutting and moisture damage resistance
- Testing parameters:
  - Sinusoidal wheel tracking test using 705 N load
  - Temperature = Target (40°C to 55°C) ± 1.0°C
- Parameters calculated:
  - Passes to Failure (to maximum depth)
  - Stripping inflection point (SIP)
- Use of trimmed gyratory specimens (or compacted slabs)
  - 150 mm diameter trimmed

Source: FHWA

HWTT Rut Depths Measured

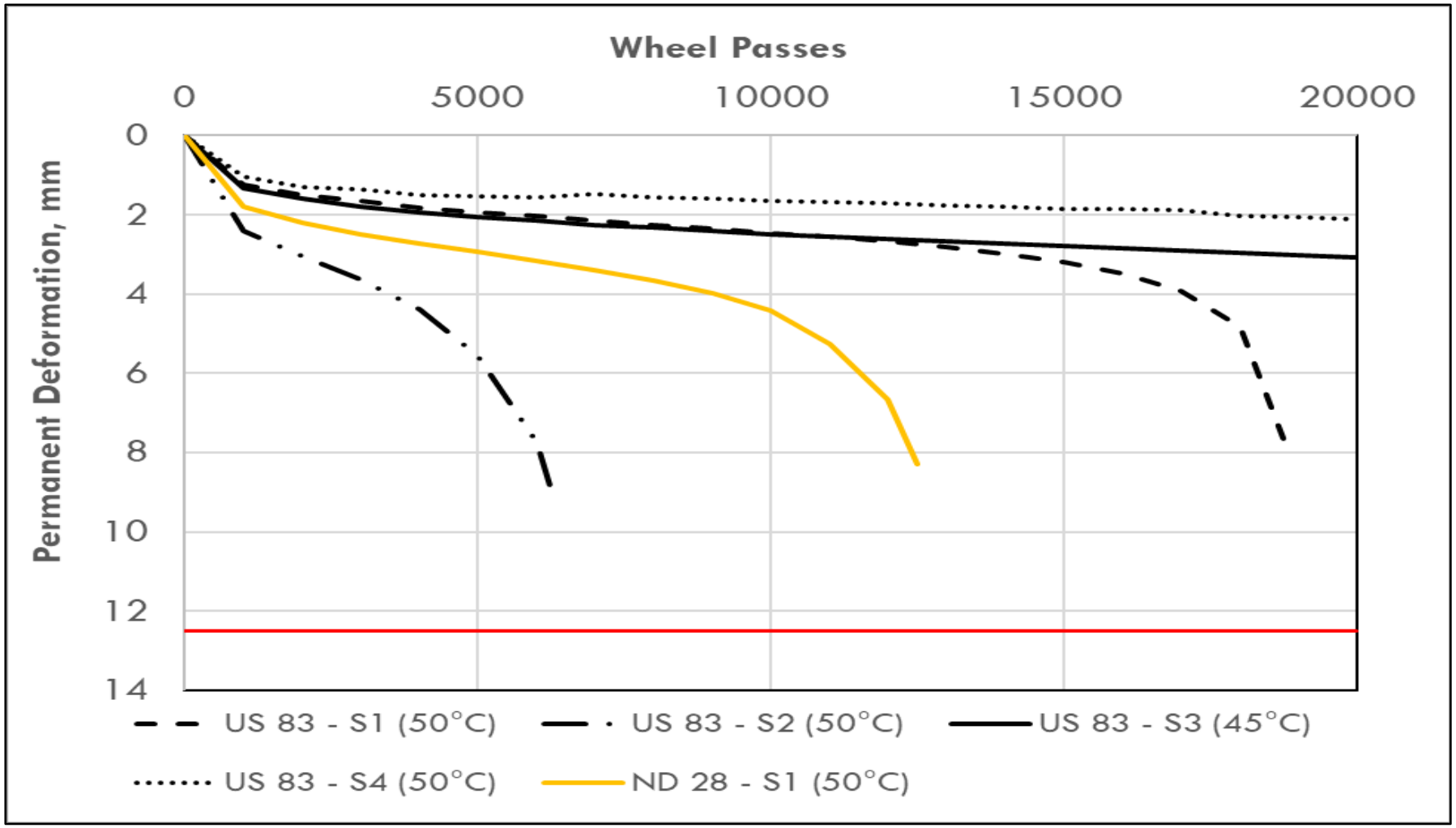
BMD Rutting



Source: FHWA

HWTT Deformation Curves with Wheel Passes

BMD Rutting



Source: FHWA

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

HWTT Results: US-83 Sample 2

BMD Rutting

All Images Source: FHWA

US-83 Sample 2 (Left Wheel Path)

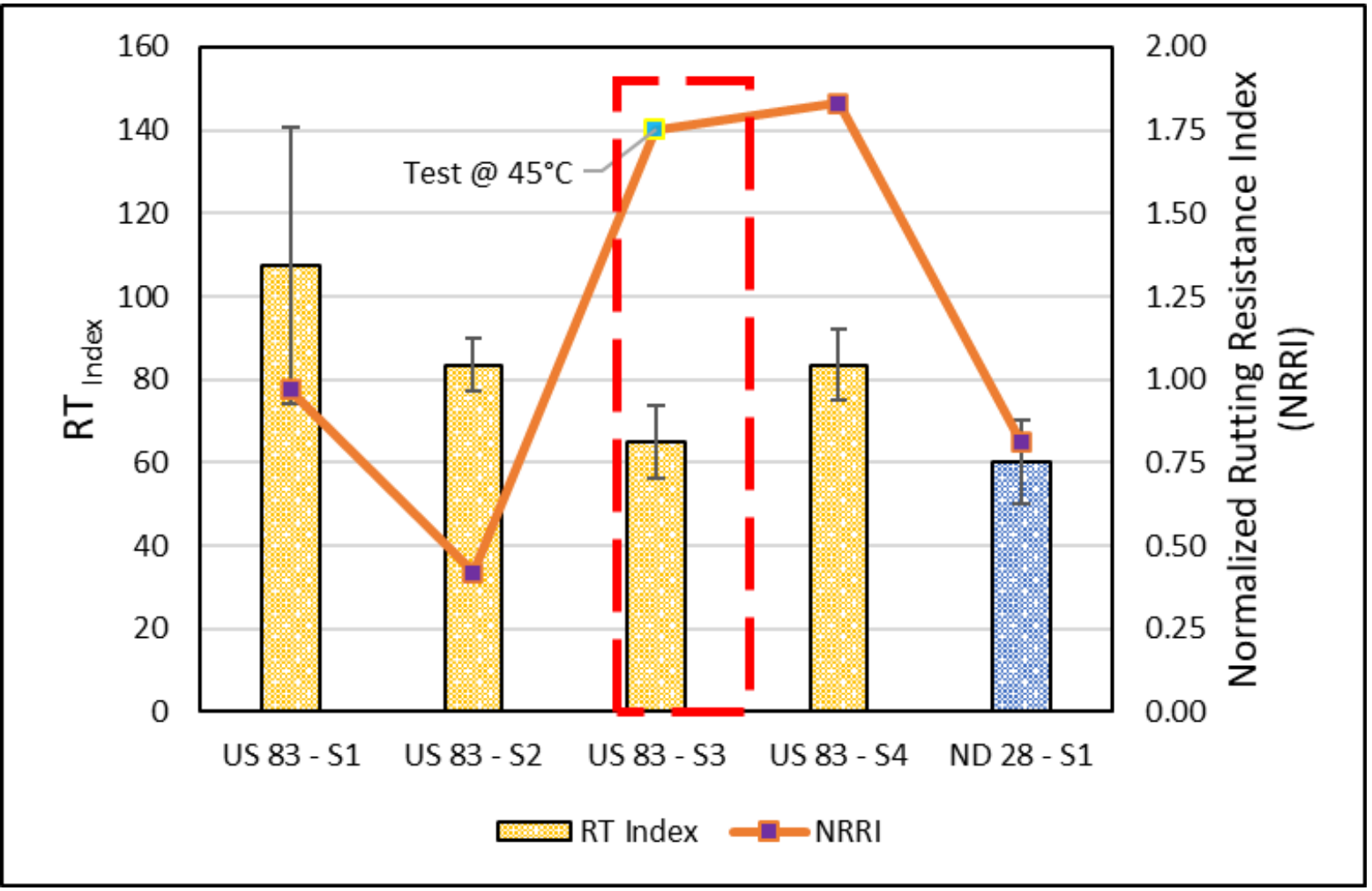
US-83 Sample 2 (Right Wheel Path)

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

RT_{Index} vs. HWTT-NRRI Test Results

BMD Rutting



Plant Production Sample	Test Temp	NRRI
US-83 Sample 1	50°C	0.97
US-83 Sample 2	50°C	0.42
US-83 Sample 3	45°C	1.75
US-83 Sample 4	50°C	1.83
ND-28 Sample 1	50°C	0.81

Source: FHWA

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation Federal Highway Administration

Summary - Cracking & Rutting Tests

BMD Results

BMD Comparison for NDDOT Mixtures

Averaged value across samples for cracking tests

Performance Test / Parameter			US-83	ND-28	Test Criterion
Cracking Performance Tests	IDEAL-CT	CT_{Index}	49.4	58.0	≥ 70
	I-FIT	FI	5.7	6.4	8
Rutting Performance Tests	IDEAL-RT	RT_{Index}	✓	✓	≥ 60
	HWTT	Rut Depth @ 20,000 passes	Samples 3 & 4 passed	Did not pass	* Plastic deformation (test temperature, moisture issue more than true rutting issue)

* *Checkmark indicates the mixture meets current typical recommended minimum criteria.*

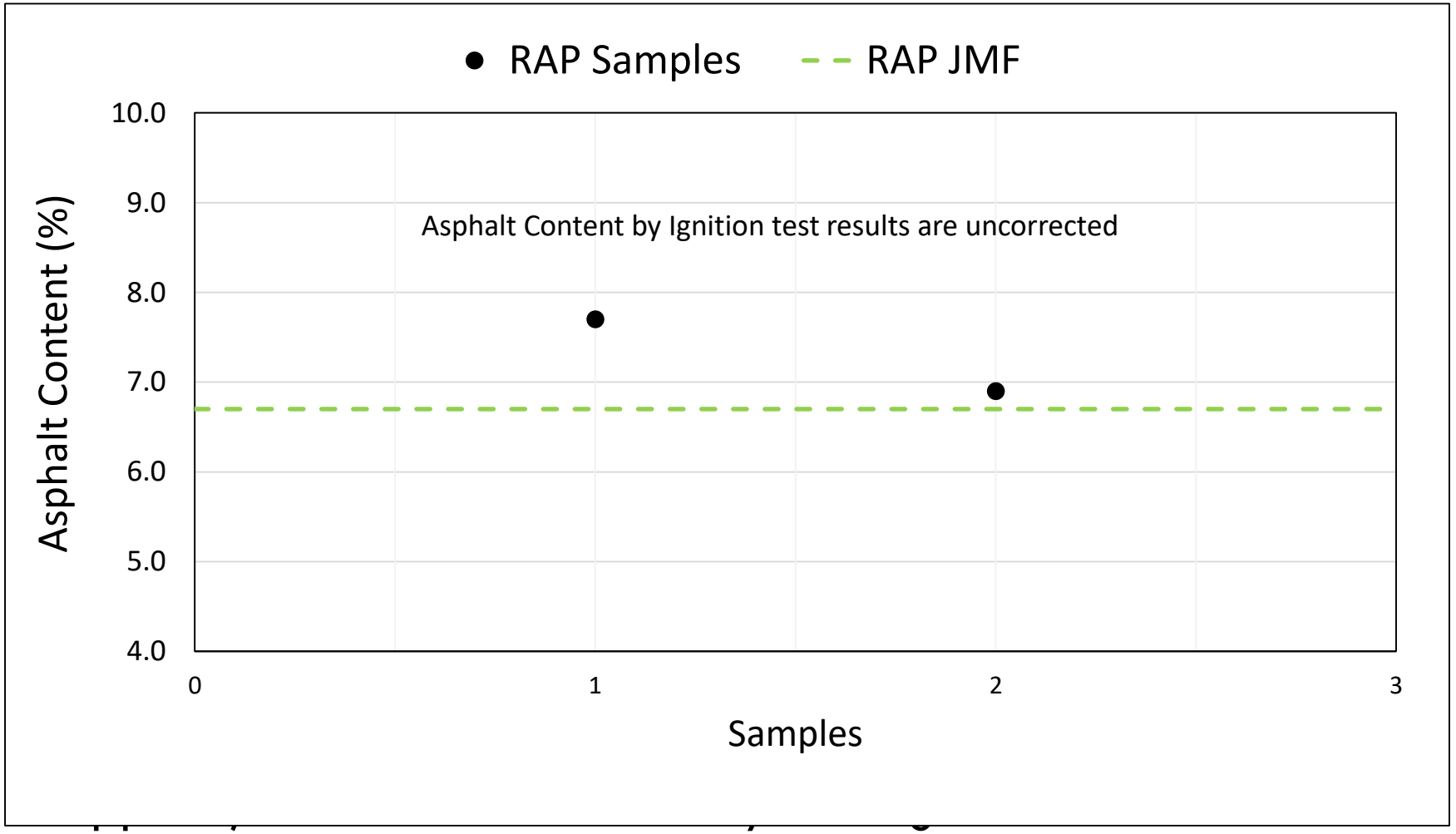
MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation Federal Highway Administration

Ignition Furnace Testing

Split-Sample Ignition Test Results

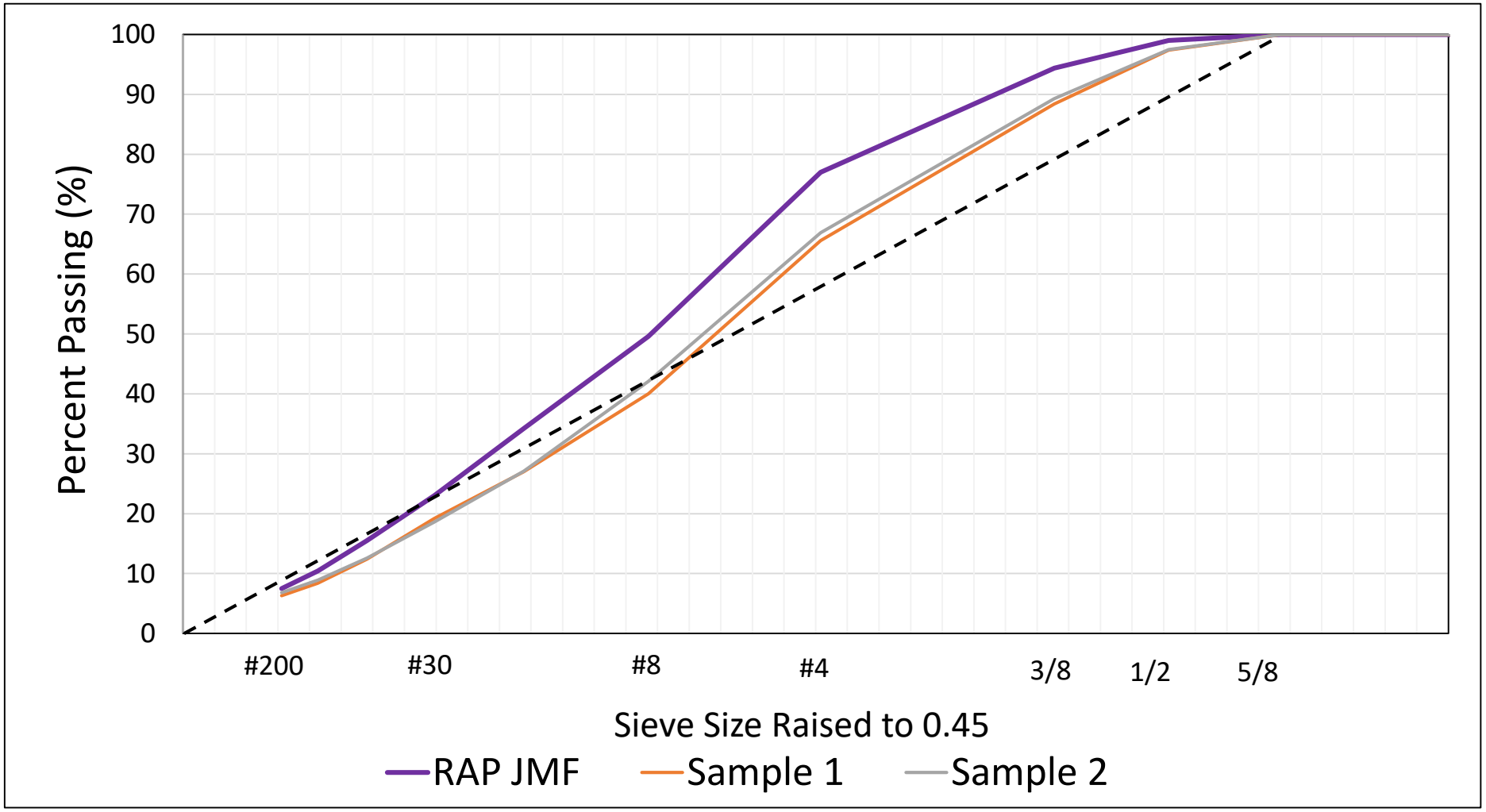
Ignition Furnace Testing



Source: FHWA

Split-Sample Post-Ignition Gradations

Ignition Furnace Testing



Source: FHWA

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

FHWA Field Test Results

MATC
MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

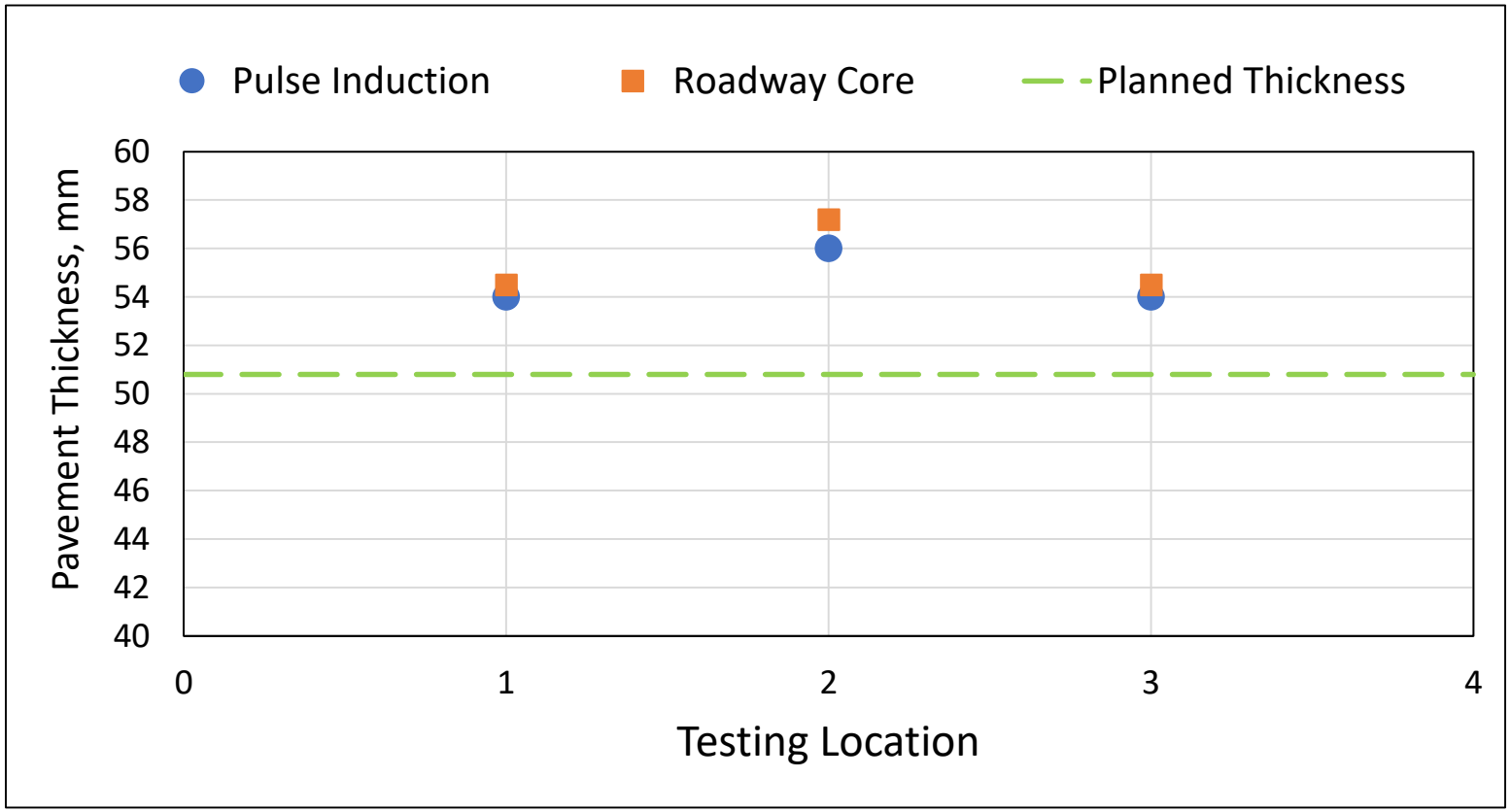
Pulse Induction Technology

- Nondestructive device to measure pavement thickness on either asphalt or concrete pavements
- Eliminates the need for taking cores
- Pulse Induction device requires preplacing a thin metal ‘target’ (plate) on the base before paving
- Distance between the plate and surface of the pavement is measured

MATC
MOBILE ASPHALT TECHNOLOGY CENTER

U.S.Department of Transportation
Federal Highway Administration

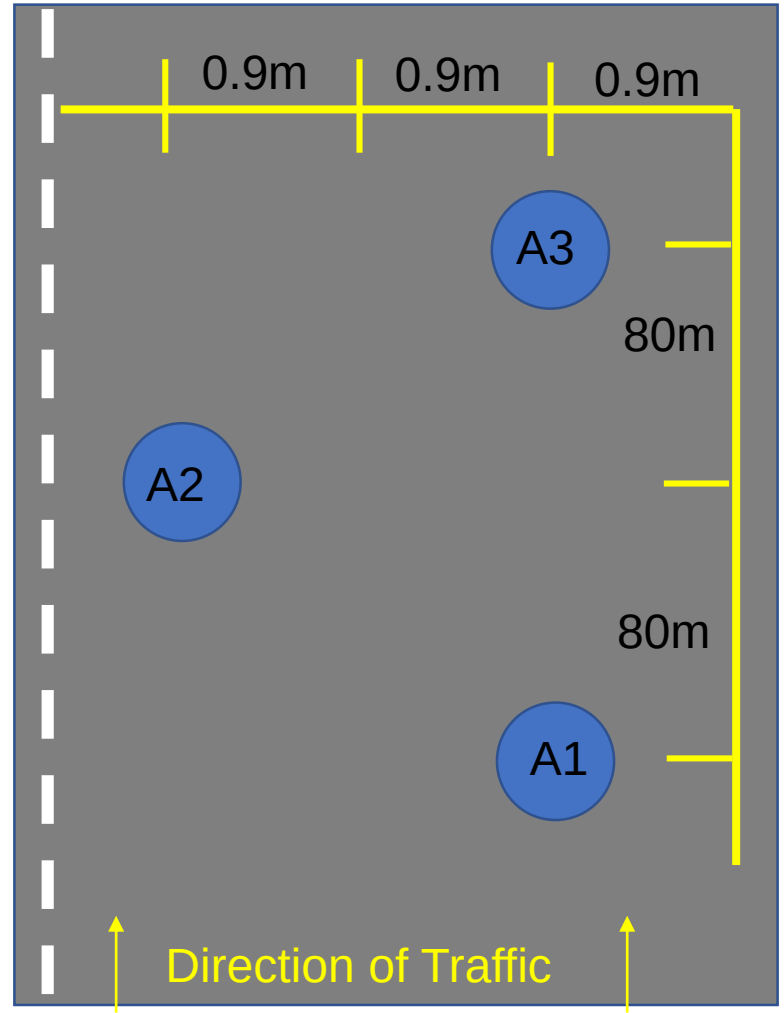
Pulse Induction Technology



Source: FHWA

Actual Measured Core thickness and Pulse Induction measurements found to be same

GPS - 48°45'47.16"N , 101°16'42.959"W
Location - US 83 N, Maxbass, ND

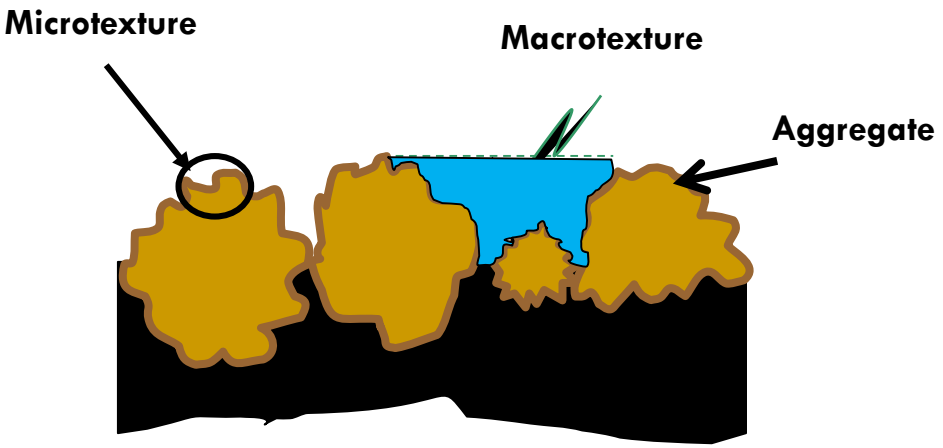


MATC MOBILE ASPHALT TECHNOLOGY CENTER
U.S. Department of Transportation Federal Highway Administration

Asphalt Pavement Macrotexture

- **Significant focus on adding life (durability) to dense-graded mixes over the past several years**
  - Concern that macrotexture may be compromised
- **Macrotexture – mix surface voids, aggregate gradation driven**
  - Provides voids/channel to evacuate water – more critical at higher speeds
  - Provides friction from hysteresis – hysteresis increases with speed – more critical at higher speeds
  - FHWA is investigating macrotexture testing procedures that could be used in mix design, mix verification, and field verification

What is texture?



Pavement Cross Section

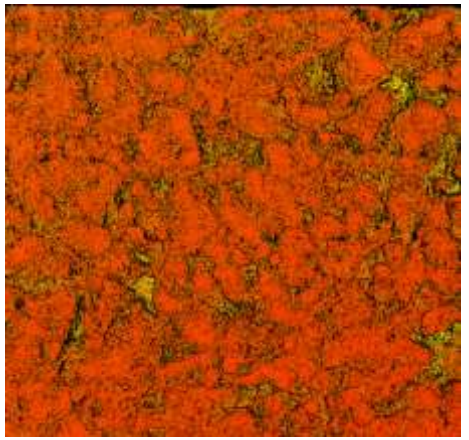
Sand Patch Test

MATC
MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

Laser Texture Scanner in Lab or Field

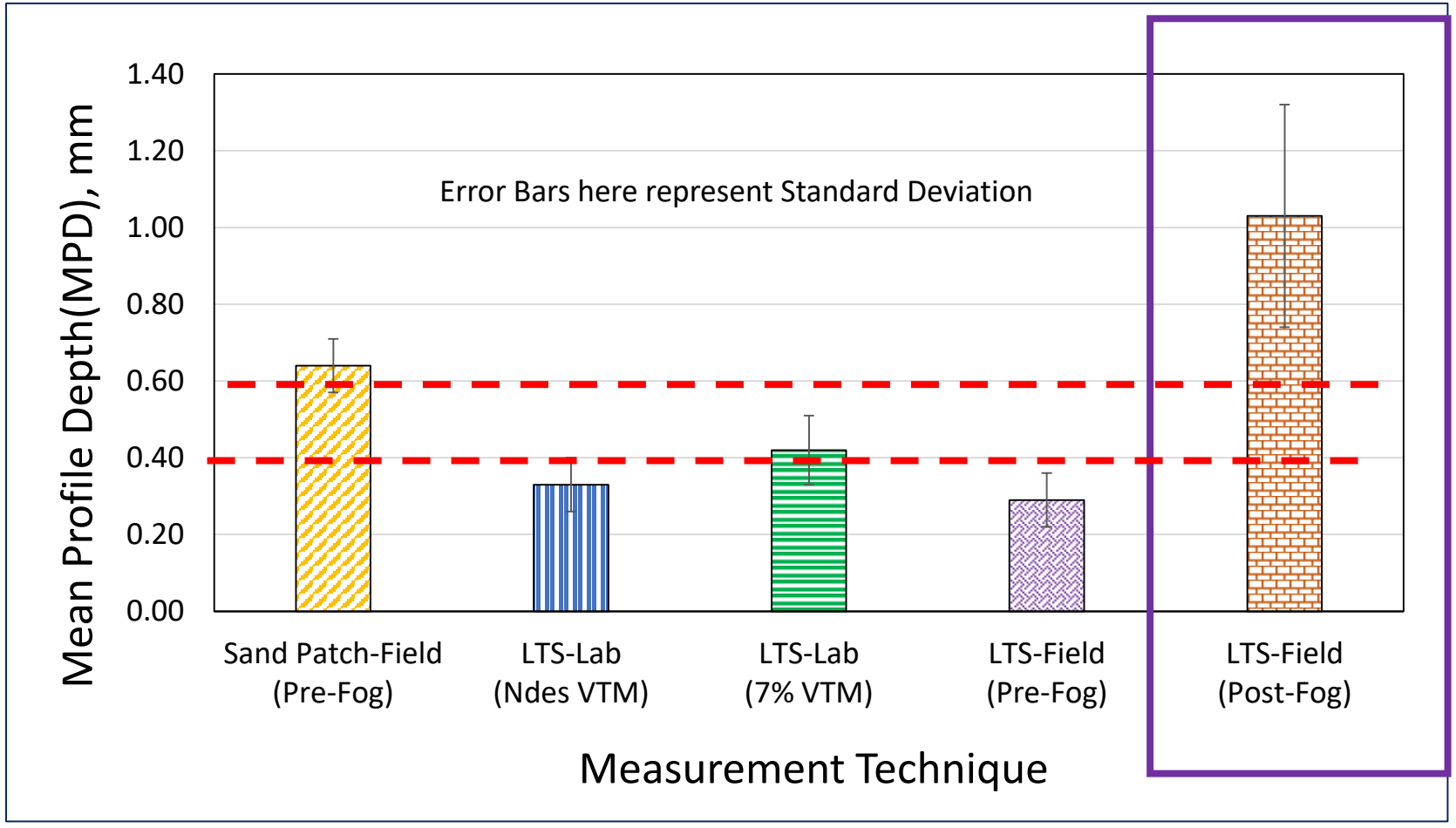
- Lightweight, portable, rapid, 3D scanner
- Utilizes a 100-mm laser line and travels 100 mm to collect a sq. area
- Measures macrotexture on freshly compacted mats in field and on cores or gyratory specimens in lab
- Reports results as a Mean Profile Depth (MPD)



MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration

Mean Profile Depth (MPD) – Field Measurements



Note:
Dulling spray type used wasn't able to sufficiently reduce reflectance

Fine Dense-graded Asphalt – MPD typically ranges from 0.015 to 0.025 in. (0.4 to 0.6 mm) according to 2008 AASHTO Guide for Pavement Friction

Observations and Comparisons from Demonstration Project

Observations from Project: Lab

Overall Demo Summary

- Sieve analysis testing of production samples showed good repeatability in gradation control
  - Volumetric properties appeared to fluctuate, due to variability in production asphalt content
- Rutting Performance Testing showed adequate rutting resistance of the two DGA mixtures
  - HWT testing showed the potential for "stripping-induced rutting" due to moisture susceptibility
  - Results from HWTT indicate that 45 deg C may be a more appropriate test temperature for ND conditions
- Cracking Performance Testing showed the two DGA surface mixtures to perform below currently-recommended minimum criteria for both IDEAL-CT and I-FIT tests
  - Reflective of variability in production asphalt content
- Ignition Furnace testing of the split-samples of US-83 RAP showed potential for accurately determining material component properties for use in developing mixture JMF
  - With appropriately applied correction factors

Observations from Project: Field

Overall Demo Summary

- Pulse Induction Technology accurately measured mat thicknesses as compared to roadway cores
  - Potential use for confirming thickness of layers as QA tool
  - Use as forensic tool confirming thickness of in-place asphalt in future
- Laser Texture Scanner measurements to determine MPD of US-83 surface mixture correlated well with the Sand Patch method
  - Pre-fog scans showed some results below MPD typical range (reported by AASHTO) for fine DGA
  - Type and use of dulling spray (post-fog sealing) would be critical for proper results
  - Potential use of LTS during mix design phase to balance durability with safety

FHWA Research Supports Improved Asphalt Performance

ABML Research

- Long-life wearing courses
  - Epoxy-modified asphalt
  - ALF(4) – impact of field density on performance
  - ALF(5) – pavement preservation
- Performance specifications
  - TFHRC "Rodeo" – performance test comparisons
  - Streamlining performance tests for production
  - Moisture damage integration and modeling
- Automation and AI
  - Example – use in performance specifications

- RAP/RAS and sustainable materials
  - Stockpile consistency
  - Mixture design optimization (integration with AI)
  - TFHRC "Rodeo" – performance test comparison
  - ALF(3)
    - Ending soon, touches on REOB, aging, RAP/RAS, structural modeling

THANK YOU!

MATC

MOBILE ASPHALT TECHNOLOGY CENTER

SPREADING ASPHALT PAVEMENT TECHNOLOGY INNOVATION

https://www.fhwa.dot.gov/matc

Leslie Myers, Ph.D., PE
MATC Program Manager – FHWA HQ
leslie.myers@dot.gov

Brendan Morris
Project Manager for MATC
brendan.morris.ctr@dot.gov

Derek Nener-Plante, PE
Pavement and Materials Engineer – Tech Transfer
derek.nenerplante@dot.gov

David Mensching, Ph.D., PE
Asphalt Research Program Manager – RD&T
david.mensching@dot.gov

MATC MOBILE ASPHALT TECHNOLOGY CENTER

U.S. Department of Transportation
Federal Highway Administration