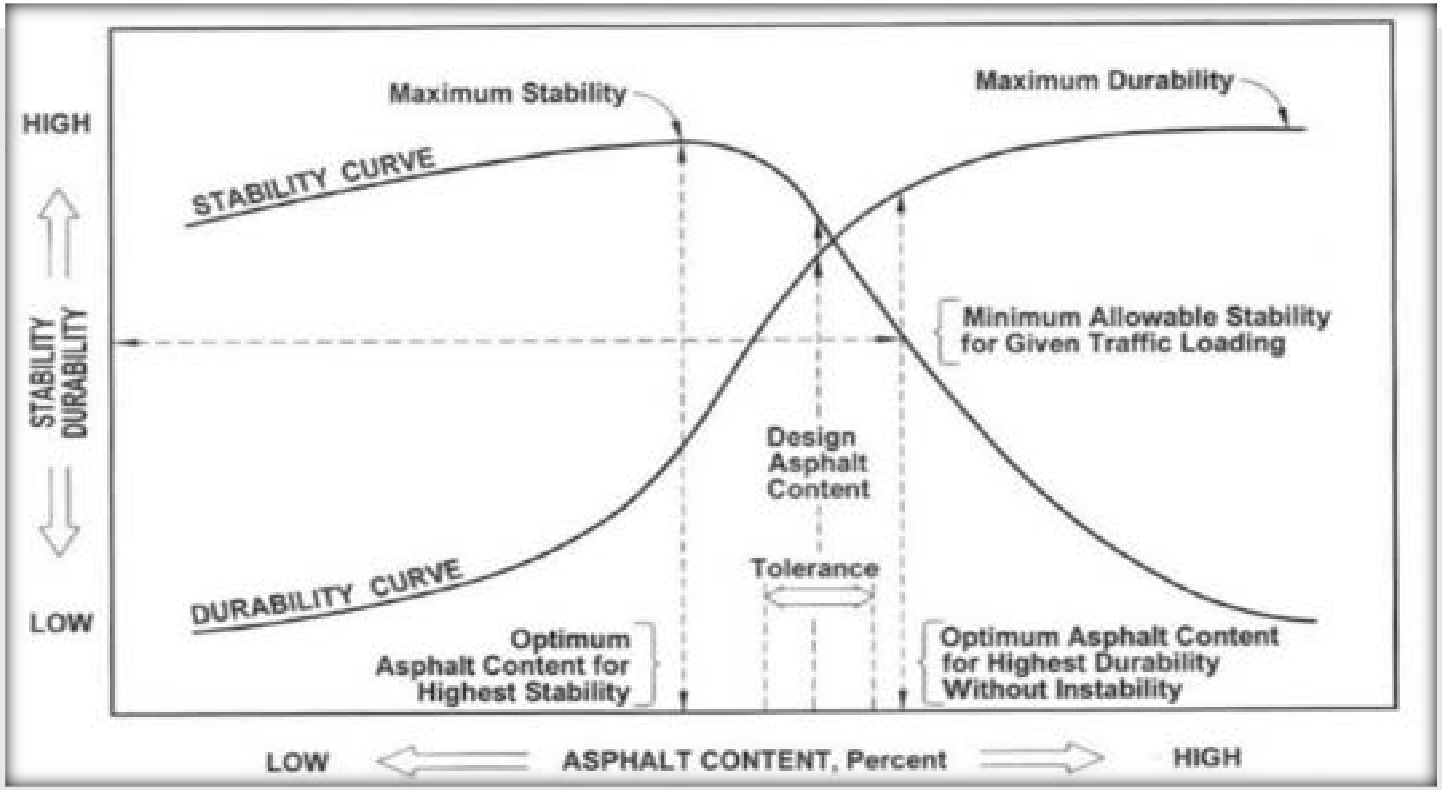
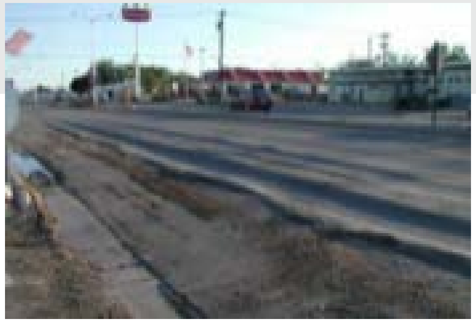
Performance Based Mix Design [Balanced Mix Design (BMD)]

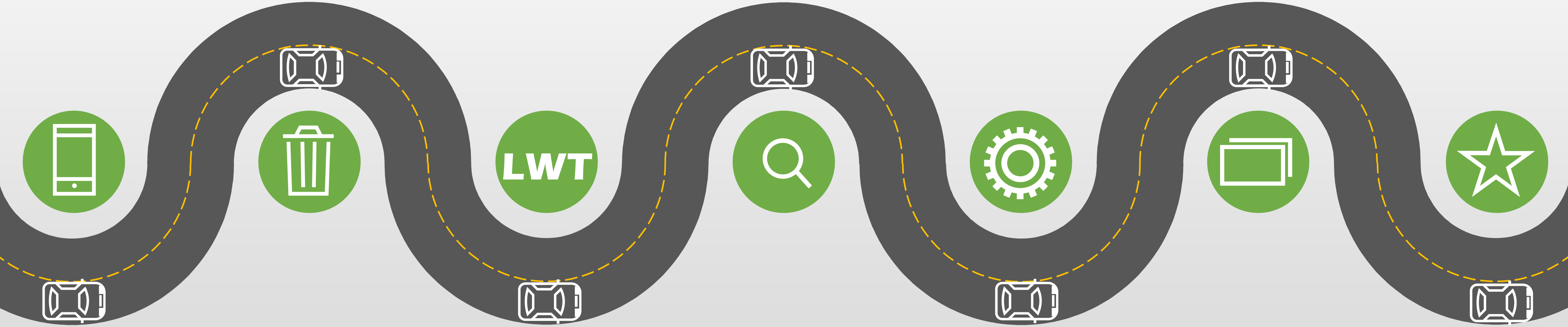
Balanced Mix Design

Mix design based on balancing mix rutting and cracking performance for the desired end use application.





Balanced Mix Design - History



1920's/40's Previous Mix Design Methods

- 1927: Hveem Stabilometer / Coheshiometer)
- 1943: Marshall (Stability / Flow)

1993: Superpave

- Level 1 Volulmetrics
- ~~Levels 2 and 3 Performance~~

Mid 1990's Loaded Wheel Testers Development/Use

- Georgia LWT
- Asphalt Pavement Analyzer (APA)
- Hamburg

Late 1990's – Present: Search for "THE" Cracking Test

- IDT, SCB, IFIT, DCT, IDEAL CT, AMPT

Mid 2010's – Present DOT BMD Specifications

- Louisiana, Illinois, New Jersey, Texas, Oklahoma, Virginia, Wisconsin
- In process: Missouri, Vermont, Utah, Minnesota, Kentucky, Oregon, Tennessee, Indiana, and others.

2018: NCHRP 20-07/Task 406 Completed by NCAT

- Framework for BMD
- AASHTO Draft Standards for BMD

2019+: Education and Implementation Efforts

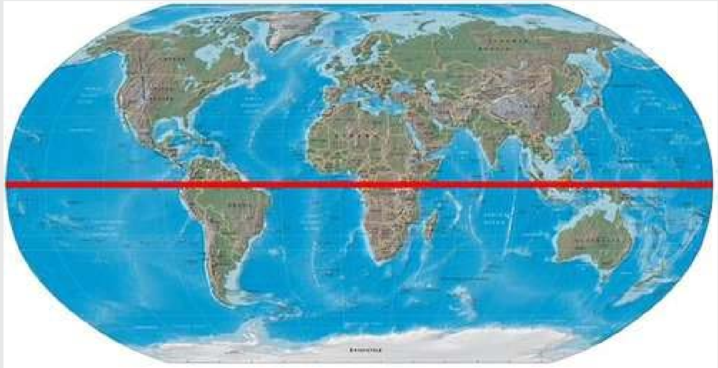
- NCAT BMD Regional Workshops
- NCAT BMD Test Track Experiments

Why Move Forward?

Since Superpave's 1993 Introduction
~ 11,225,000,000 Tons of Mix Produced in U.S.
= 19,548,938 miles @ 12 ft wide 1.5 in thick

- **Each day,** approximately 1.4 Million tons of HMA are produced in the U.S. (M-F production basis)
- Equivalent to ~2500 lane miles @ 12' wide and 1.5" thick
- New York to Las Vegas

- Pave around the earth's equator **~ 782 times.**



- Pave to the moon and back! **~ 41 times**

The Time is Now to Move Forward!

CRH

In Idaho, did you know….

- **Each day,** approximately 11,000 tons of HMA are produced in Idaho (M-F production basis)
- Equivalent to ~20 lane miles @ 12' wide and 1.5" thick

Nampa to Boise

IDAHO	Reported Values		Estimated Values	
	2018	2019	2018	2019
Tons of HMA/WMA Produced	Tons, Millions		Tons, Millions	
Total	1.5	1.5	2.9	2.7
DOT	0.8	0.8	1.5	1.5
Other Agency	0.4	0.3	0.8	0.5
Commercial & Residential	0.3	0.4	0.6	0.7

NAPA: Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage 2019

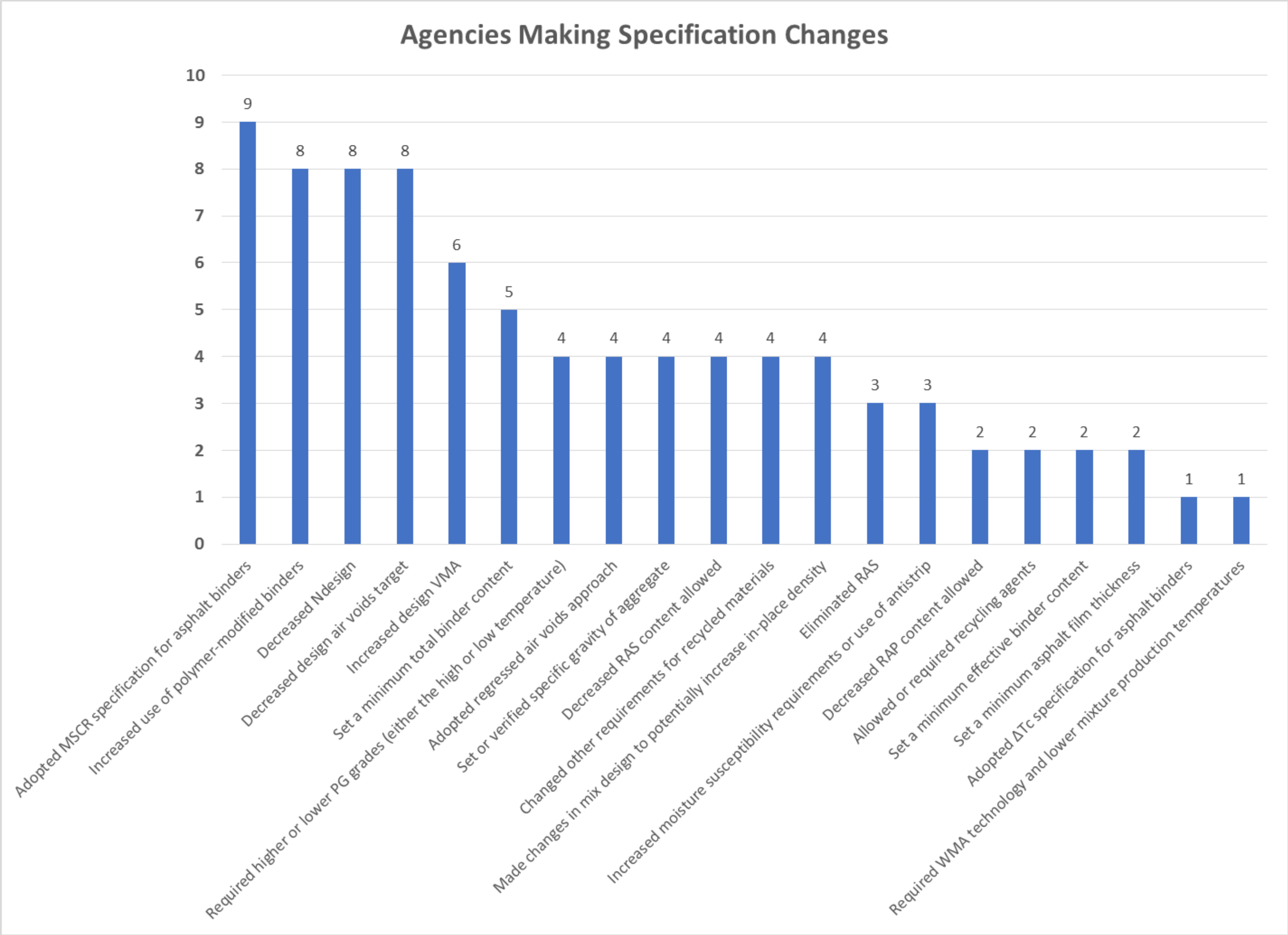
Why Move Forward?

- **Problems:**
  - Volumetrics alone can not adequately evaluate mix variables, such as recycle, warm-mix additives, polymers, rejuvenators, and fibers.
- **Solutions:**
  - **Increase understanding** of the factors which drive mix performance
  - **Design for performance** and not just to "the spec".
  - **Start thinking** outside of long held "rules and constraints"
  - **Innovate!**

|

Current Mix Design Specifications

- **Most of today's mix design specifications are heavily scripted and follow a "recipe" or standardized approach.**
  - Aggregates and grading
  - Volumetrics (Va, VMA, VFA, D/A, etc.)
  - Binder grade and/or minimum %
  - RAP and/or RAS
- **While this <u>may</u> work, there are problems**
  - What happens when the recipe fails?
  - Specifications have become ***convoluted and confounded***
    - Existing specified items compete against each other
    - New requirements get added and nothing gets removed
      - "Spec Book Creep"



All these changes are being made to yield a better performing mixture.

Question: Why Not Just Test the Mix?

CRH

Balanced Mix Design Approaches

- Several approaches available.
- **CAUTION:** Adding performance testing to an existing specification without allowances can make for an unachievable, unrealistic outcome.
  - Allowances: volumetric property target ranges, thresholds, etc.

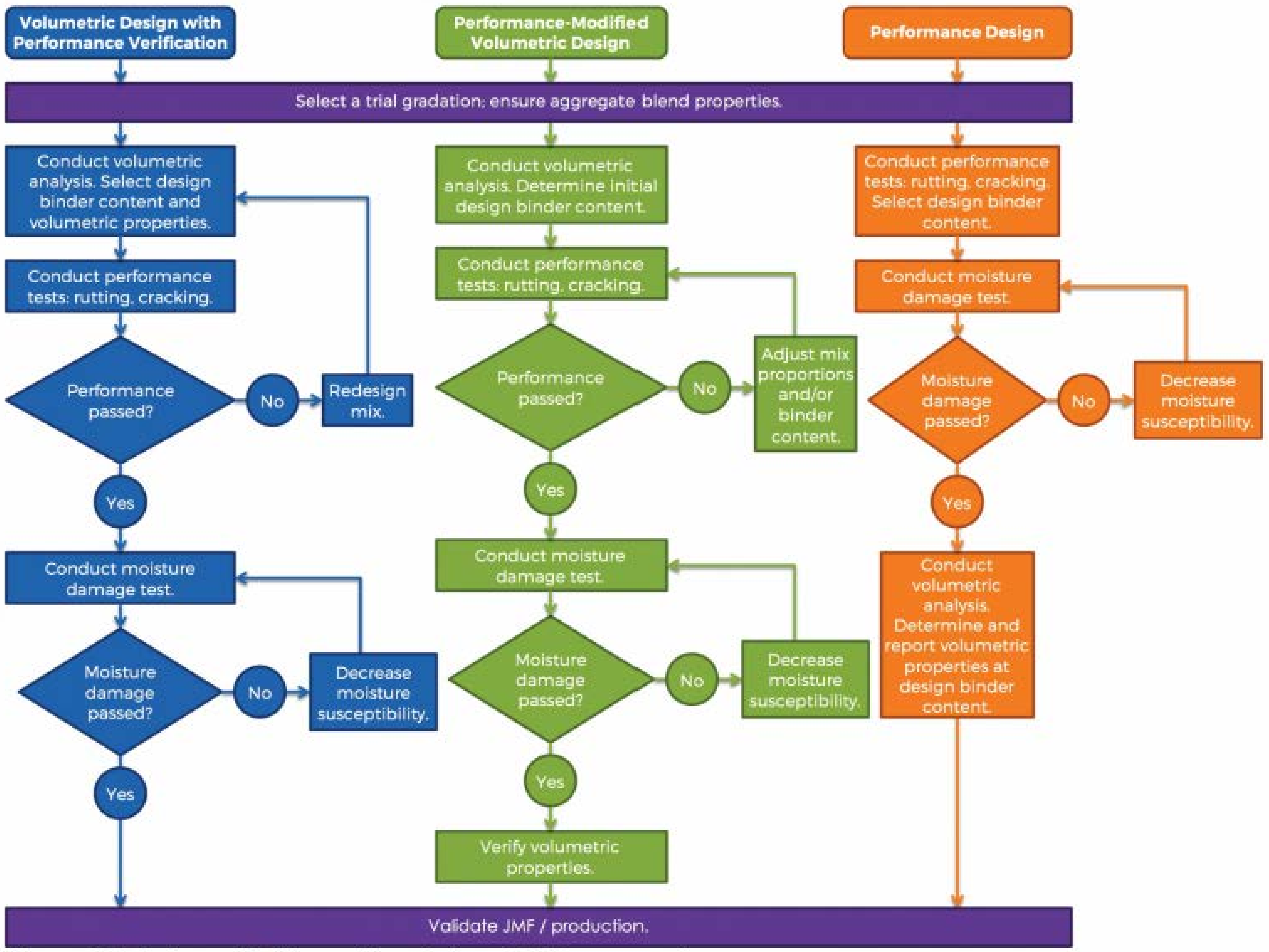
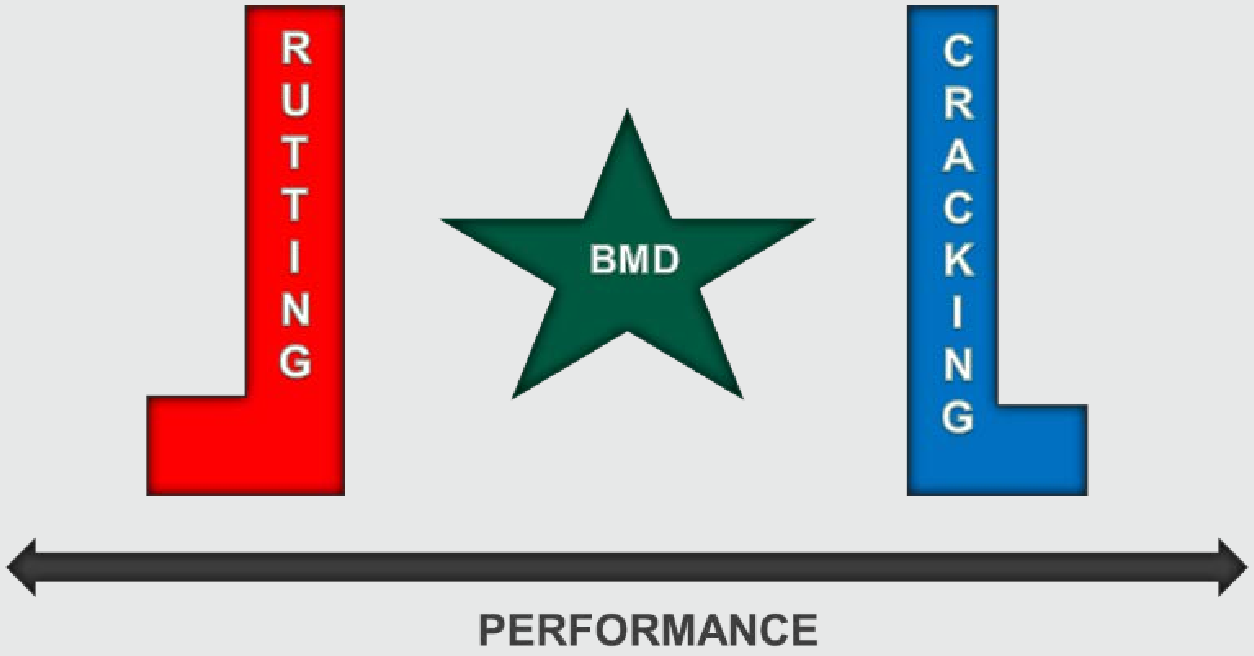
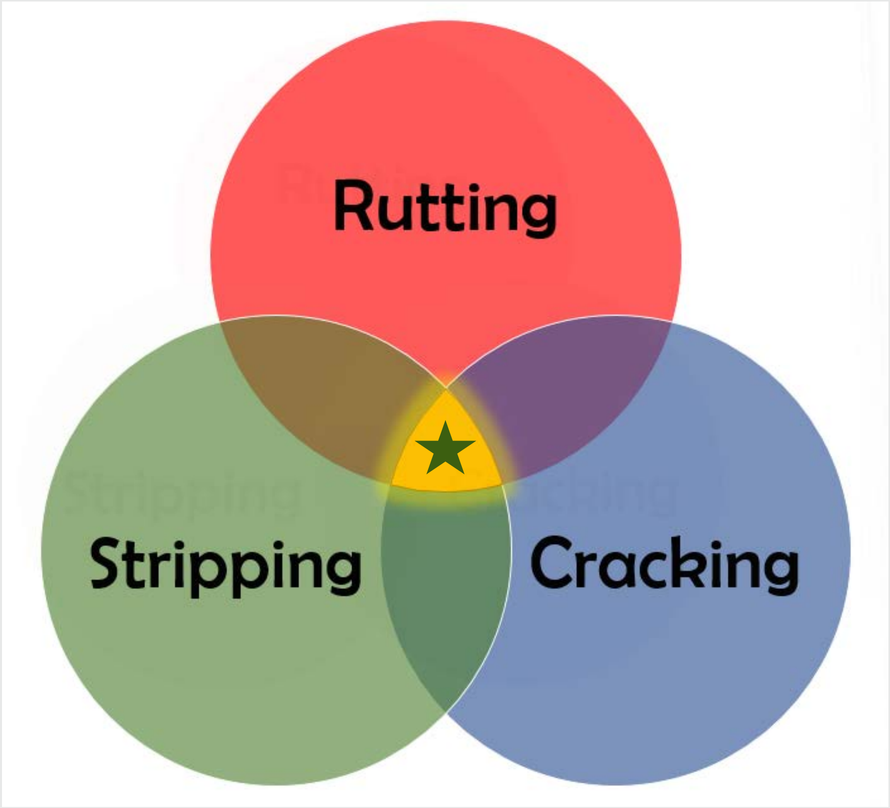


Figure 3-2. Schematic illustration of three BMD approaches.

Performance Tests (Rutting and Cracking) for BMD





Main Pavement Distresses Observed in the Field

Moisture Damage

Permanent Deformation

Fatigue Cracking

Thermal Cracking

Reflection Cracking

Top-down Cracking

Thermal Cracking

Reflection Cracking

Fatigue Cracking

Top-down Cracking

Permanent Deformation

Moisture Damage

Table 3-12. Commonly used asphalt mixture performance tests. http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(406)_Revised_final_report.pdf

Mixture Property	Laboratory Test	Test Standard	Test Parameter(s)	Criteria Available
Thermal Cracking	Disk-Shaped Compact Tension Test*	ASTM D7313-13	Fracture Energy	Yes
	Indirect Tensile Creep & Strength Test	AASHTO T 322-07	Creep Compliance & Tensile Strength	Yes
	Semi-Circular Bend (SCB) Test*	AASHTO TP 105-13	Fracture Energy	Yes
	Thermal Stress Restrained Specimen Test	BS EN12697-4	Fracture Temperature & Fracture Strength	No
Reflection Cracking	Disk-Shaped Compact Tension Test*	ASTM D7313-13	Fracture Energy	No
	Texas Overlay Test*	TxDOT Tex-248-F NJDOT B-10	Cycles to Failure & Fracture Properties	Yes
	Illinois Flexibility Index Test	AASHTO TP 124-16	Flexibility Index	Yes
Bottom-Up Fatigue Cracking	Direct Tension Cyclic Fatigue Test	AASHTO TP 107-14	Damage Characteristic Curve & Fatigue Model	No
	Flexural Bending Beam Fatigue Test*	AASHTO T 321 ASTM D7460	Cycles to Failure Fatigue Equation	No
	IDT Fracture Energy Test	N/A	Fracture Energy	No
	Illinois Flexibility Index Test	AASHTO TP 124-16	Flexibility Index	Yes
	SCB at Intermediate Temperature*	LaDOTD TR 330-14 ASTM D8044-16	Strain Energy Release Rate	Yes
	Texas Overlay Test*	TxDOT Tex-248-F	Cycles to Failure Fracture Properties	Yes
Top-Down Fatigue Cracking	Direct Tension Test	N/A	Fracture Parameters	No
	IDT Energy Ratio Test*	N/A	Dissipated Creep Strain Energy & Energy Ratio	No
	Illinois Flexibility Index Test	AASHTO TP 124-16	Flexibility Index	Yes
Rutting	Asphalt Pavement Analyzer	AASHTO T 340	Rut Depth	Yes
	Flow Number	AASHTO T 378	Flow Number	Yes
	Hamburg Wheel Tracking Test	AASHTO T 324	Rut Depth	Yes
	Superpave Shear Tester	AASHTO T 320-07	Permanent Shear Strain	No
	Incremental Repeated Load Permanent Deformation	AASHTO TP 116-15	Minimum Strain Rate	Yes
Moisture Susceptibility	Hamburg Wheel Tracking Test	AASHTO T 324	Rut Depth & Stripping Inflection Point	Yes
	IDT Strength Test	AASHTO T 283	Tensile Strength Ratio & Wet IDT Strength	Yes
	Moisture Induced Stress Tester	ASTM D7870	Changes in G_{mb} & Visual Observations of Stripping	No

Note: * Tests selected at the Cracking Test Workshop in NCHRP Project 09-57 (Zhou et al., 2016)

Rutting Tests

Rutting Tests

- Rutting can be evaluated with several available tests based on the user preference.

Hamburg Wheel Test (HWT)

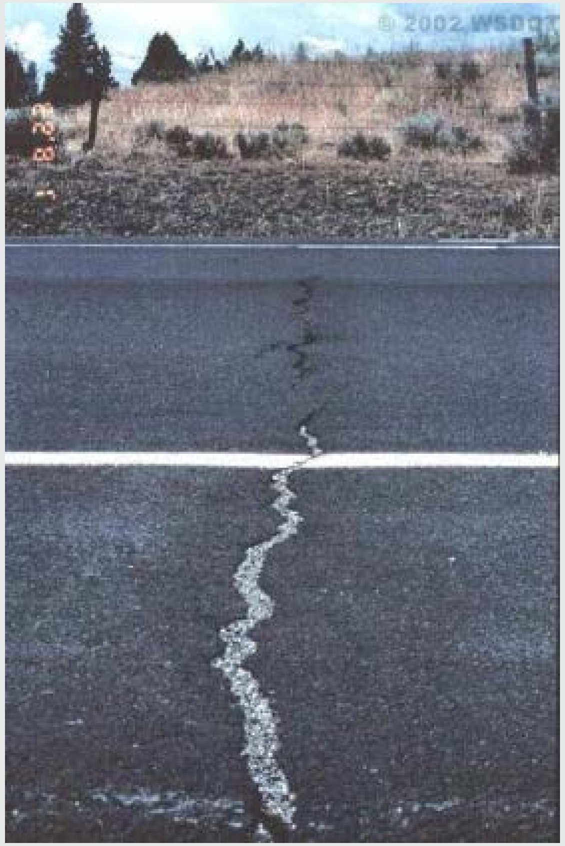
Asphalt Pavement Analyzer (APA)

IDT - HT

AMPT Flow Number / Dynamic Modulus

Most commonly used tests. Hamburg gaining popularity due to moisture susceptibility analysis.

Durability Testing (Cracking)



Durability/Cracking Evaluation

- Durability/cracking evaluation is substantially more complicated than stability with aging being one main variable.
- No general consensus the best test(s) or the appropriate failure threshold.
- MANY different tests are available with more being developed.
- Main question is “What is the anticipated mode of distress?”

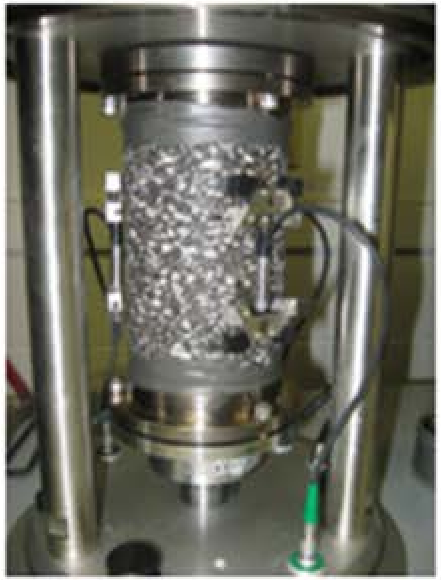
Fatigue (Bottom Up or Top Down) Related Cracking Tests

Bottom Up | Bottom Up / Top Down | Bottom Up | Bottom Up / Top Down

Bending Beam Fatigue

Texas Overlay Test

SCB
- LTRC – Jc
- IFIT



Direct Tension Cyclic Fatigue, S-VECD

IDEAL CT ★

CRH

Thermal Cracking Tests

IDT Creep Compliance

TSRST

SCB at Low Temp

Disk Shaped Compact Tension (DCT) ★

CRH

Reflection (Reflective) Cracking Tests

Disk Shaped Compact Tension (DCT)

Texas Overlay Test ★

SCB (IFIT)

Leading Tests *Today*

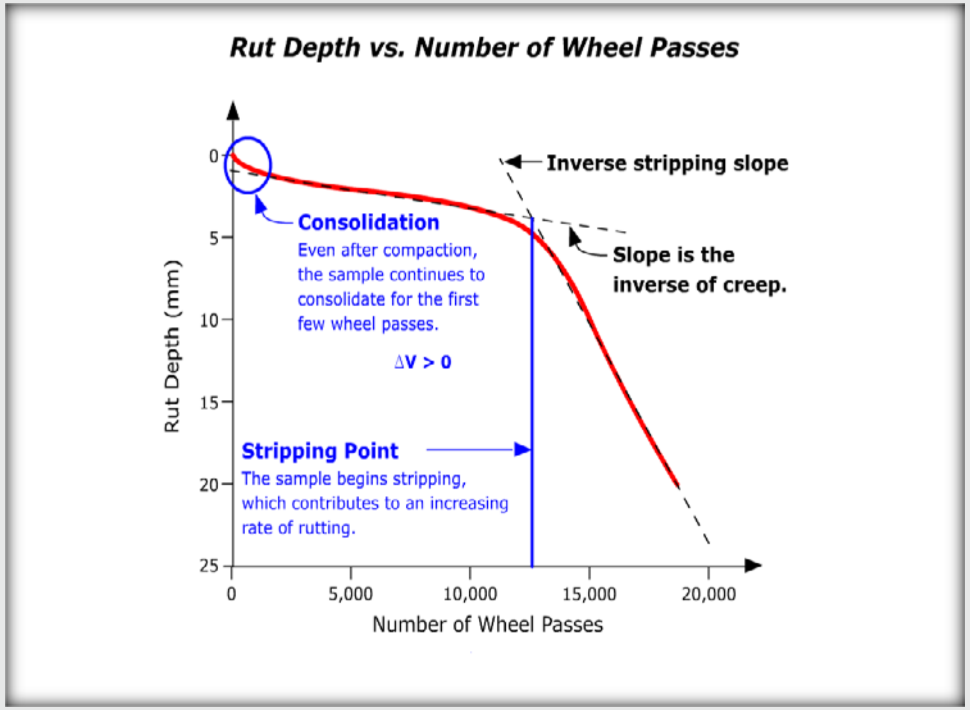
Hamburg Wheel Test (HWT)

Illinois Flexibility Index Test (IFIT)

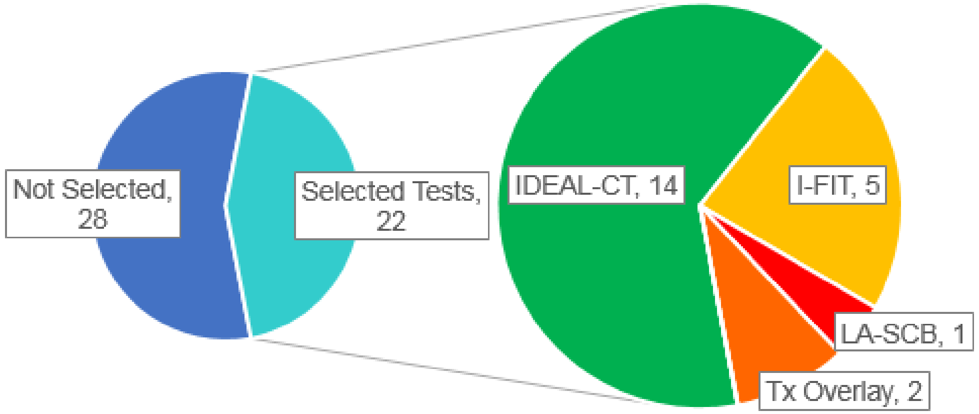
IDEAL CT

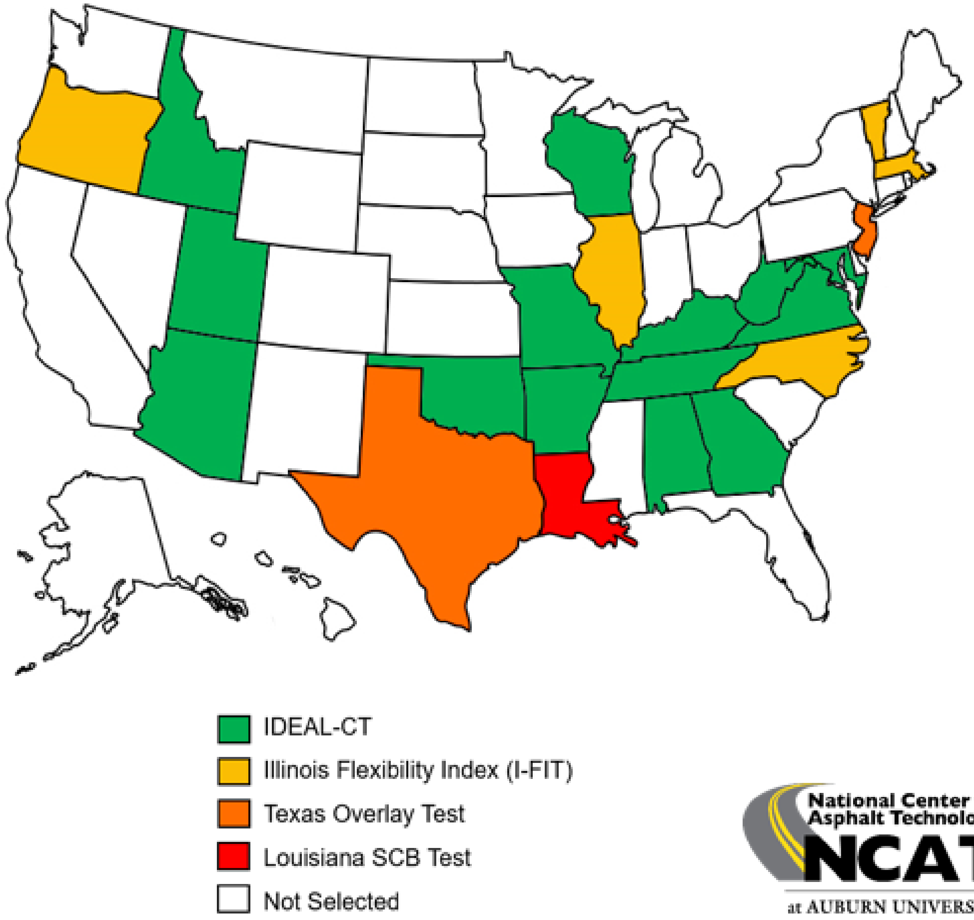
Hamburg Wheel Test (HWT)

- AASHTO T324
- Rutting performance combined with moisture susceptibility
- No. of passes (20,000)
- Temperature (~50C)
- Air voids (7 ± 0.5%)
- Steel Wheel
- Submerged specimen



Leading Cracking Tests

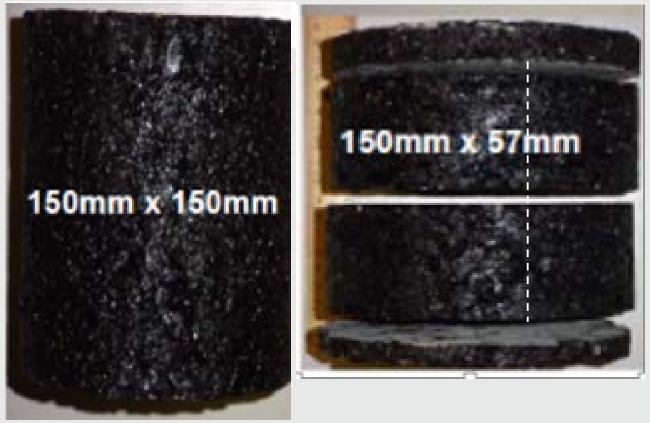




National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

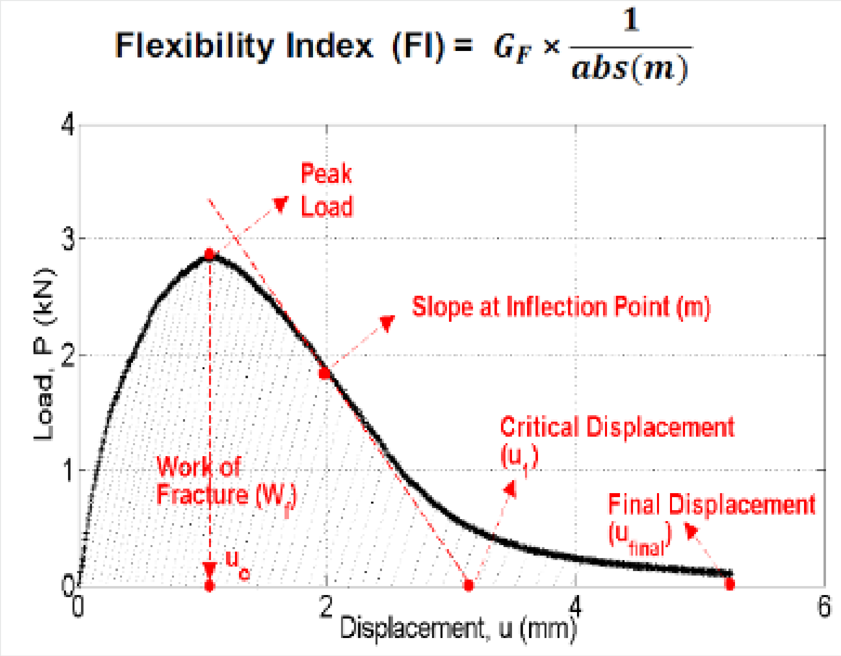
CRH

Illinois Flexibility Index Test (I-FIT)



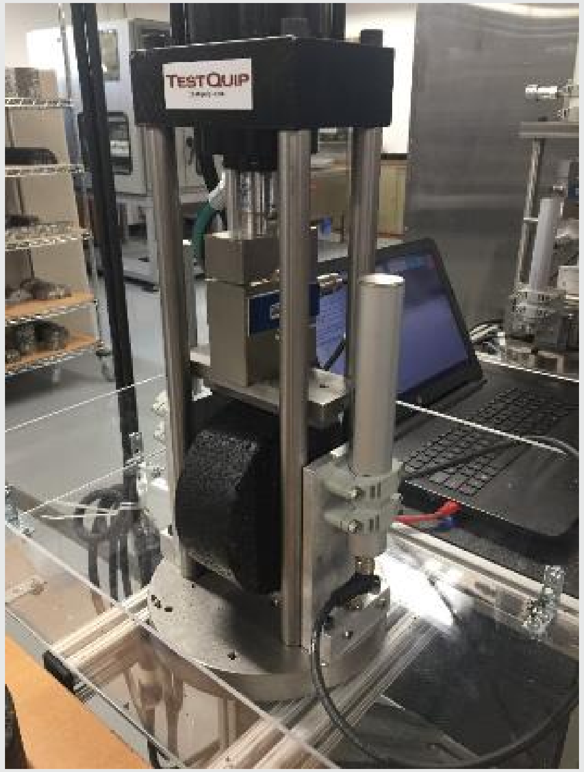
- AASHTO TP 124
- Temperature 25C
- Air voids (7 ± 0.5%)

Notch



CRH

Indirect Tension Asphalt Cracking Test (IDEAL-CT)



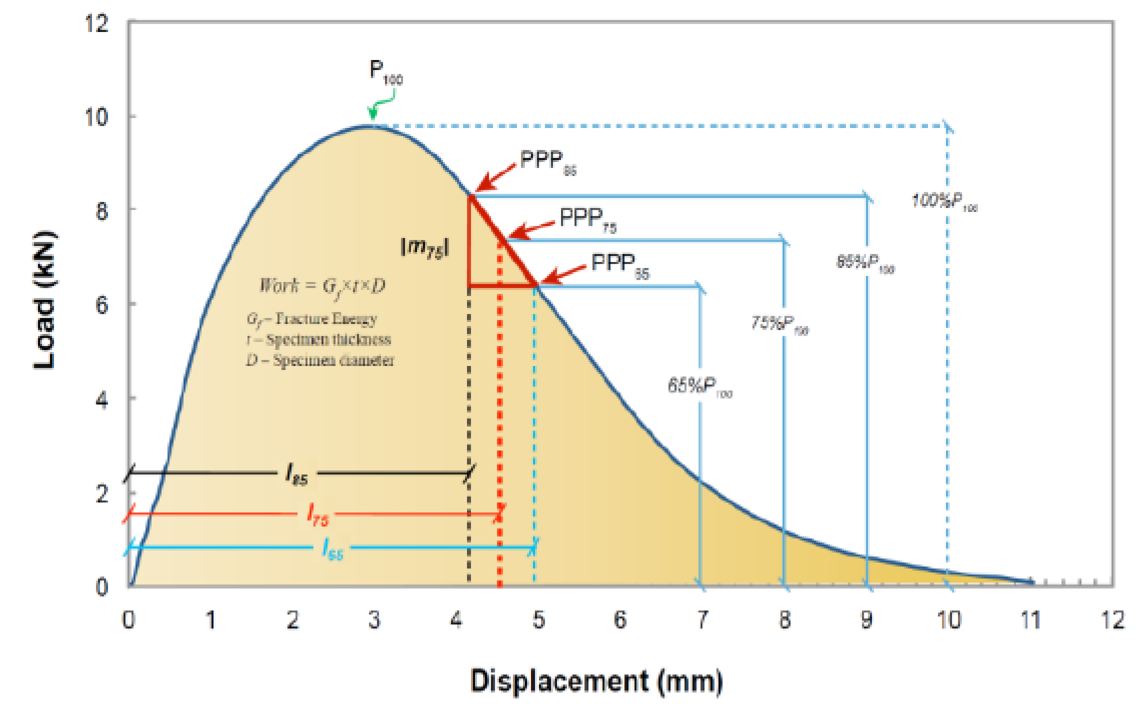


Figure 2. *Illustration of the PPP75 Point and Its Slope* $|m_{75}|$

- ASTM D8225
- Similar to IFIT
- Faster, easier to test.
- 62 mm height, uncut specimen

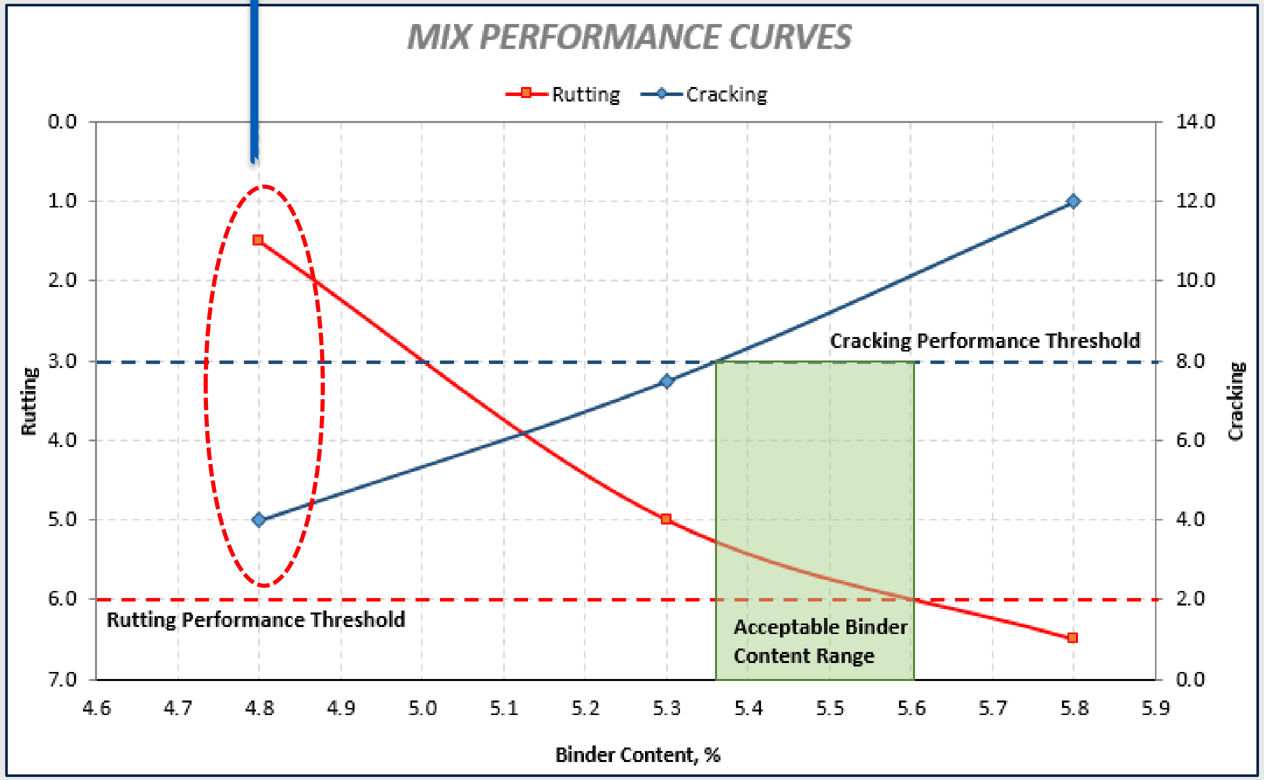
Texas A&M Transportation Institute

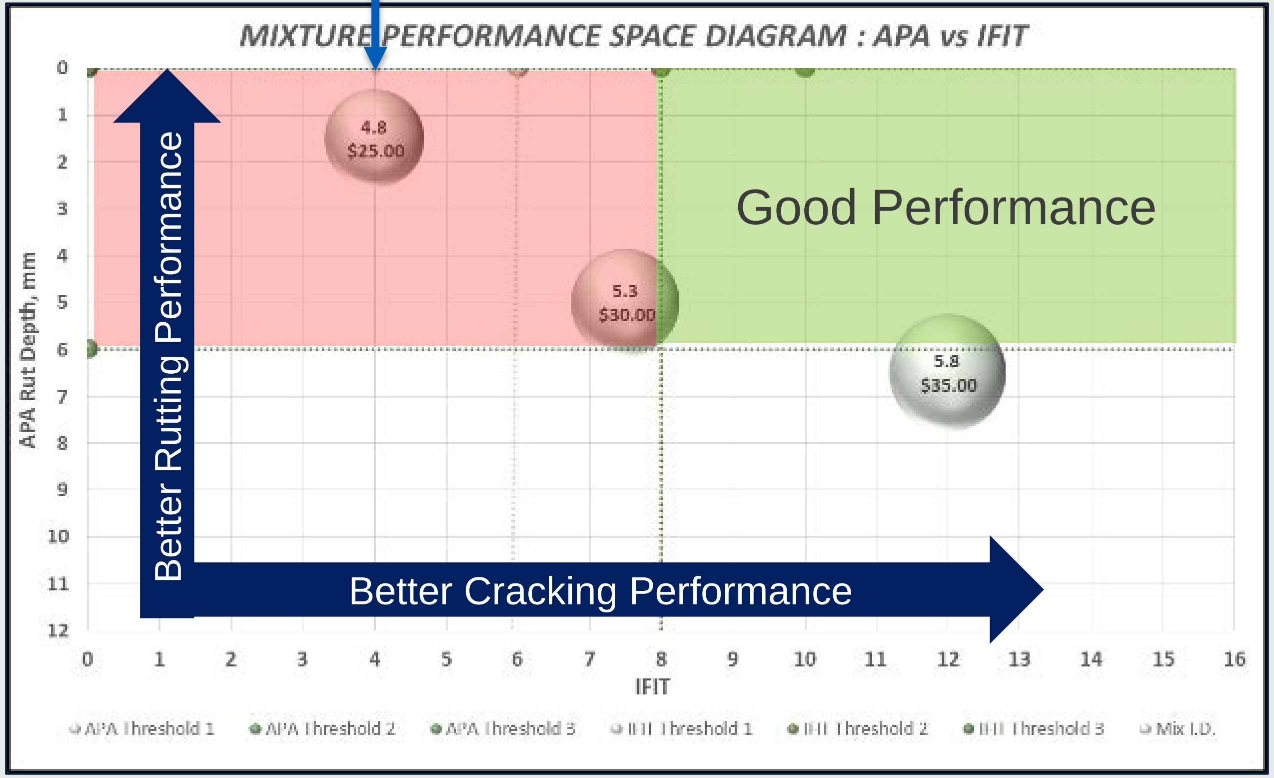
Indirect Tension Asphalt Cracking Test (IDEAL-CT)
NCHRP IDEA Project 195: Development of an IDEAL Cracking Test for Asphalt Mix Design, Quality Control and Quality Assurance

$$CT_{Index} = \frac{G_f}{|m_{75}|} \times \left(\frac{l_{75}}{D}\right)$$

CRH

Total Mixture Performance





What are the States Doing?

Illinois Balanced Mix Design

- Phased implementation
  - 26 Pilot projects 2016/2017
  - All Interstate projects 2019
  - **Full implementation 2020**

Hamburg

+

IFIT

(1) Hamburg Wheel Test Criteria. The maximum allowable rut depth shall be 0.5 in. (12.5 mm). The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth criteria shall be based on the high temperature binder grade of the mix as specified in the mix requirements table of the plans.

Illinois Modified AASHTO T 324 Requirements 1/

PG Grade	Number of Passes
PG 58-xx (or lower)	5,000
PG 64-xx	7,500
PG 70-xx	15,000
PG 76-xx (or higher)	20,000

(3) I-FIT Flexibility Index (FI) Criteria1/. The minimum allowable FI shall be as follows:

Minimum Flexibility Index (FI)	
HMA	8.0
SMA	8.0

Louisiana Balanced Mix Design

- Louisiana DOT implemented BMD in the 2016 Standard Specifications for **all DOT projects.**

\+

Hamburg

Louisiana SCB

Table 502-6[1]
Asphalt Concrete General Criteria

Nominal Max., Size Agg.	0.5 inch (12.5 mm)			0.75 inch (19 mm)			1.0 inch (25 mm)				1.5 inch (37.5 mm)	SMA
Type of Mix	Incidental Paving[2,9]	Wearing Course		Wearing Course	Binder Course		Binder Course		Base Course[9]	ATB[8,9]	Base Course[9]	Wearing
Level[3]	A	1	2	2	1	2	1	2	1	1	1	2
LWT, max. rut-design, mm @ # passes, @ 50°C	10 @ 10,000	10 @ 20,000	6 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	12 @ 20,000	10 @10,000	12 @ 20,000	6 @ 20,000
Dust/Effective Asphalt Ratio, %		0.6 – 1.6										
SCB, min, Jc, KJ/m2 @ 25°C	All mix design level 1 must meet minimum 0.5 Jc , All mix design level 2 must meet minimum 0.6 Jc.											

- *Hamburg research began prior to 2000*
- *SCB research began in 2004*

New Jersey Balanced Mix Design

- NJDOT High RAP Design incorporates BMD

Asphalt Pavement Analyzer (APA)

+

Texas Overlay Tester

Table 902.13.03-2 Performance Testing Requirements for HMA HIGH RAP Design				
	Requirement			
	Surface Course		Intermediate and Base Course	
Test	PG 64-22	PG 64E-22	PG 64-22	PG 64E-22
APA @ 8,000 loading cycles (AASHTO T 340)	≤ 7 mm	≤ 4 mm	≤ 7 mm	≤ 4 mm
Overlay Tester (NJDOT B-10)	≥ 200 cycles	≥ 275 cycles	≥ 100 cycles	≥ 150 cycles

Virginia Balanced Mix Design

- New (April 2019) ***Special Provision for High Reclaimed Asphalt Pavement (RAP) Content Surface Mixes Designed Using Performance Criteria***


Asphalt Pavement Analyzer (APA)


IDEAL CT

Cantabro

Table 1
Performance Testing Requirements

Test	Procedure	Specimens	Criteria
AASHTO T340 – Method of Test for Determining Rutting Susceptibility of HMA Using the Asphalt Pavement Analyzer (APA	8,000 passes @ 64°C	• 2 replicates of 2 pills (APA Jr) • Gyratory pill: 150 mm dia., 75 ± 2 mm ht. • Compact to 7±0.5% air voids • Lab produced mix: condition loose mix for 2 hours at the design compaction temperature prior to compacting • Plant produced mix: Minimize any cooling of and bring specimens to the compaction temperature and compact immeadiately.	Rutting ≤ 8.0mm
AASHTO TP 108-14 (2018). Standard Method of Test for Determining the Abrasion Loss of Asphalt Mixture Specimens (Cantabro)	300 rotations 30-33 rot/min	• 3 replicates • Gyratory pill: 150 mm dia., 115 ± 5 mm ht. • Compact to N_{design}, report air voids • Lab-produced mix – condition loose mix for 2 hours at the design compaction temperature prior to compacting	Mass loss ≤ 7.5%
ASTM XX- Determination of Cracking Tolerance Index of Asphalt Mixture Using the Indirect Tensile Cracking Test at Intermediate Temperature (CT_{Index} a.k.a. "Ideal CT")	• Condition specimens 25±1°C for 2±0.5 hr • load Apply load using load-line displacement control at rate of 50 mm/minute, record load to peak and through failure; analyze.	• 3 replicates • Gyratory pill- 150mm dia., 62 ± 2mm ht. • Compact to 7±0.5% air voids • Lab-produced mix – condition loose mix for 4 hours at the design compaction temperature prior to compacting	CT_{Index} ≥ 70

Texas DOT Balanced Mix Design

Special Specification 344

Superpave Mixtures - Balanced Mix Design

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, Superpave (SP) mixture of aggregate and asphalt binder mixed hot in a mixing plant utilizing a Balanced Mix Design (BMD) approach.

Hamburg

+

Texas Overlay Tester

Table 11A
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000[2]
PG 70		15,000[3]
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to lower the Ndesign level to no less than 35 gyrations.
2. May be decreased to no less than 5,000 passes when shown on the plans.
3. May be decreased to no less than 10,000 passes when shown on the plans.

Table 11B
Overlay Test Requirements

Mixture Property	Test Method	Surface Mixtures	Intermediate and Base Mixtures
Critical Fracture Energy (CFE),[1] in.-lb/in.^{2}, Min	Tex-248-F	1.0	1.0
Crack Progression Rate (CPR),[1] Max		0.45	0.55

1. If the requirement is not meet, the Engineer may approve the mix if the average number of cycles is ≥300 cycles.

Oklahoma DOT Balanced Mix Design

OKLAHOMA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION
FOR
BALANCED MIX DESIGN REQUIREMENTS

These Special Provisions amend and where in conflict, supersede applicable sections of the 2009 Standard Specifications for Highway Construction, English and Metric and applicable Special Provisions.

NOTE: It is the intent of this special provision to allow the contractor/producer the option to design and produce HMA/WMA meeting Balanced Mix Design (BMD) requirements that does not necessarily meet the requirements of 2009 Standard Specifications and current Special Provisions. In addition, during production, JMF tolerances of 2009 Standard Specifications and current Special Provisions will be applied. An open communication should be established during the HMA/WMA design process between the contractor/producer and ODOT Materials Division Bituminous Branch to facilitate the approval process. The final HMA/WMA design will be at the discretion of the ODOT Bituminous Branch Manager.

Table 708:11a
Hamburg Rut Test Requirements[a, b]

Binder Grade	Minimum Number of Passes to 12.50 mm Rut Depth, Tested at 122 °F (50C)
PG 64	10,000
PG 70	15,000
PG 76	20,000

Table 708:8
Mix Design Properties of Laboratory Molded Specimens

Property	Superpave			SMA	PFC	RBL
	PG64	PG70	PG76	PG76	PG76	PG64
Cantabro	Report Only					
I-FIT	≥ 8.0	≥ 8.0	≥ 8.0	---	---	---

Notes:
Hamburg + IFIT @ 7% voids, Cantabro @ 4%
Short term aging used (R30)

+

Hamburg **IFIT**

Vermont AOT Balanced Mix Design

(Under Development)

Hamburg

+

IFIT

VERMONT AGENCY OF TRANSPORTATION

(a) Hamburg Wheel Tracker (HWT) Criteria. The maximum allowable rut depth at 20,000 passes shall be based on the mix type specified in Table 1 below.

TABLE 1 - DESIGN CRITERIA FOR HWT TEST

Hamburg Wheel Tracking (HWT) Test Properties	Mix Type and Nominal Maximum Aggregate Size (inches)		
	Type IIS (3/4)	Type IIIS (1/2)	Type IVS (3/8)
Rut depth in mm (inches)	12.5 (0.50)	12.5 (0.50)	10.0 (0.40)
Stripping Inflection Point (SIP)	≥ 15,000 passes		
Test Method	AASHTO T 324		
Test Temperature in °C (°F)	45 ± 1.0 (113 ± 1.8)		

(b) Illinois Flexibility Index Test (I-FIT) Criteria. I-FIT testing to measure the cracking susceptibility of the mix design shall be completed in accordance with AASHTO TP 124. The minimum allowable Flexibility Index (FI) for each mix type shall be as specified in Table 2 below.

TABLE 2 - DESIGN CRITERIA FOR I-FIT TEST

Mix Type and Nominal Maximum Aggregate Size (inches)	Minimum Flexibility Index (FI)
Type IIS (3/4)	10.0
Type IIIS (1/2)	10.0
Type IVS (3/8)	10.0

Kentucky TC Balanced Mix Design
(Under Development)

KENTUCKY TRANSPORTATION CABINET

- Special Note
  - Hamburg
  - IDEAL CT (KYCT Index)

Hamburg

IDEAL CT

3.3 Hamburg Testing. Perform the rut resistance analysis (Hamburg) in accordance to AASTHO T-324, not to exceed 20,000 passes for all bituminous mixtures during the mix design phase and production. For mix design approvals, submit Hamburg results on the Department MixPack. For Class 4 mixtures, submit ingredient materials to the Division of Materials for informational verification.

3.3.1 Hamburg Testing Frequency. Perform testing and analysis per lot of material. The plant produced bituminous material sampled for the Hamburg test does not have to be obtained at the same time as the acceptance and KYCT sample. If the Hamburg test sample is not obtained at the same time as the KYCT sample, determine the Maximum Specific Gravity of the KYCT sample in accordance with AASHTO T-209 coinciding with the Hamburg specimens.

3.2 KYCT Testing. Perform crack resistance analysis (KYCT) in accordance with the current Kentucky Method for KYCT Index Testing during the mix design phase and during the plant production of all surface mixtures. For mix design approvals, submit KYCT results on the Department MixPack. For Class 4 mixtures, submit ingredient materials to the Division of Materials for informational verification.

3.2.1 KYCT Frequency. Obtain an adequate sample of hot mix asphalt to insure the acceptance testing, gradation, and KYCT gyratory samples can be fabricated and is representative of the bituminous mixture. Acceptance specimens shall be fabricated first, then immediately after, fabricate the KYCT samples with the gyratory compactor in accordance with Section 2.4 of this Special Note. Analysis of the KYCT specimens and gradation will be required one per sublot produced from the same asphalt material and at the same time as the acceptance specimen is sampled and tested.

Data Collection first, Threshold Setting afterwards!

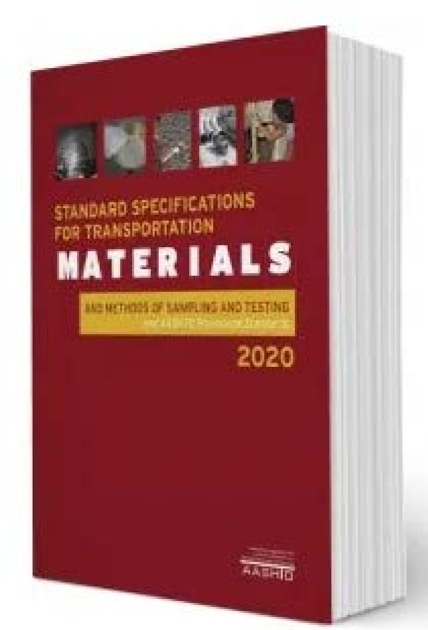
CRH

BMD Momentum

New Published AASHTO Standards in 2020!

- **PP 105 – Balanced Design of Asphalt Mixtures (standard practice document)**
  - Serves as a framework for balanced design of asphalt mixtures that governs the development of an asphalt mixture job mix formula based on mixture volumetric properties, performance-based/related test results, or both.
  - May also be used to provide a preliminary selection of mix parameters as a starting point for performance prediction analyses.

- **MP 46 – Balanced Mix Design (standard specification document)**
  - Specifies minimum performance testing requirements for balanced design of asphalt mixtures.



1. **PROJECT:** Investigation of Balanced Mixture Design for New York State Asphalt Mixtures
   Center for Advanced Infrastructure and Transportation, $80000, 2019, Active 2019-1
2. **PROJECT:** Balanced Mixture Design Implementation Support
   Wisconsin Department of Transportation, $150000, 2019, Active 2019-0
3. **PROJECT:** Impact of Production Variability on Balanced Mix Design in Virginia
   Virginia Department of Transportation, $362921, 2019, Active 2
4. **PROJECT:** Framework of Asphalt Balanced Mix Design (BMD) for New England Transportation Agencies
   Maine Department of Transportation, 2019, Active 2
5. **PROJECT:** Use of the IDEAL-CT Test for Pavement Cracking to Achieve a Balanced Asphalt Mix Design
   Mountain-Plains Consortium, $174000, 2019, Active 2
6. **PROJECT:** Development of a Balanced Mix Design (BMD) Procedure for Tennessee Asphalt Mixtures
   Tennessee Department of Transportation, $179,925.00, 2018, Active
7. **PROJECT:** Development of a Balanced Mix Design Method in Oregon
   Oregon Department of Transportation, $85000, 2017, Active
8. **PROJECT:** 2305 - Implement Balanced Asphalt Mix Design in Oklahoma
   Oklahoma Department of Transportation, $111332, 2017, Completed
9. **PROJECT:** Support for Balanced Asphalt Mixture Design Specification Development in Missouri
   Missouri Department of Transportation, $283609, 2017, Active 2017-05-18
10. **PROJECT:** Develop Guidelines and Design Program for Hot-Mix Asphalts Containing RAP, RAS, and Other Additives through a Balanced Mix-Design Process
    Texas Department of Transportation, $523750, 2016, Active 2016-06-21
11. **PROJECT:** Balanced Mix Design for Asphalt Mixtures: High RAP Field Trials
    Virginia Department of Transportation, $304843, 2019, Active 2019-06-20
12. **PROJECT:** Feasibility and Implementation of Balanced Mix Design in Nebraska
    Nebraska Department of Transportation, $119942, 2018, Active 2018-07-01
13. **PROJECT:** SPR-4114: Performance Balanced Mix Design for Indiana's Asphalt Pavements
    Indiana Department of Transportation, $242591, 2017, Completed 2017-01-01
14. **PROJECT:** TRC1802 - Performance-Based Asphalt Mixture Design (PBD) for Arkansas
    Arkansas Department of Transportation, $$354,263, 2017, Active 2017-07-26

What are Some Steps to <u>Prepare</u> for BMD?

1. Remember, it's still aggregate, asphalt, and air!
2. Be aware of what's happening
3. Participate in conferences/meetings to learn more
4. Understand the impact of BMD on asphalt binder demand, recycle potential / availability
5. Evaluate your readiness (e.g., capabilities / needs). Do you need to more people, training, equipment?
6. Act to increase readiness
7. Establish baseline (test your mixes to see where you are at)
8. Optimize mixes (performance + economics)
9. Embrace the opportunity!
10. **Be the leader!**

"By failing to prepare, you are preparing to fail."

- Ben Franklin

Will a BMD Have a Higher Binder Content?

- Depends…
  - How is the current “recipe” specification established?
  - Are your mixes currently “dry”?
  - What part of the state do your operate?
    - Varying aggregate gravities w/ current specifications yield “different” mixes.
- **Evaluate your mixes now and find out!**
  - For initial evaluation, use IFIT w/ 8 or IDEAL CT w/ 70

Will BMD Mixes Cost More to Produce?

- Depends…
  - What is your **current performance** relative to a BMD requirement?
  - What’s the overall provided opportunity to **innovate**?
    - Recycle
    - Aggregates
    - Grading
    - Additives

|

What Do I See Happening!

- Most states will move toward a version of BMD within the next 3 years.
- Vast number of tests will be consolidated down into probably 4 to 5 test.
- Regional type approach may be used (similar tests and perhaps thresholds).
- Mix designs opened up to allow for alternate volumetrics / materials provided performance is achieved.
- Production testing conducted via mix design and/or surrogate tests (quicker) to ensure design = JMF.
- **Mix performance will be increased.**

More Information

Training Course:
http://www.eng.auburn.edu/research/centers/ncat/education/training/industry/balanced-mix.html

Task 406 Development of a Framework for BMD
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(406)_Revised_final_report.pdf

Thank You

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