MANAGING ASPHALT PAVEMENTS
CONFERENCE AND TRADE SHOW
MAY 15-17, 2023 ★ WACO, TEXAS

Demystifying RAM (Recycled Asphalt Materials)

Amy Epps Martin
Texas A&M University

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TxDOT

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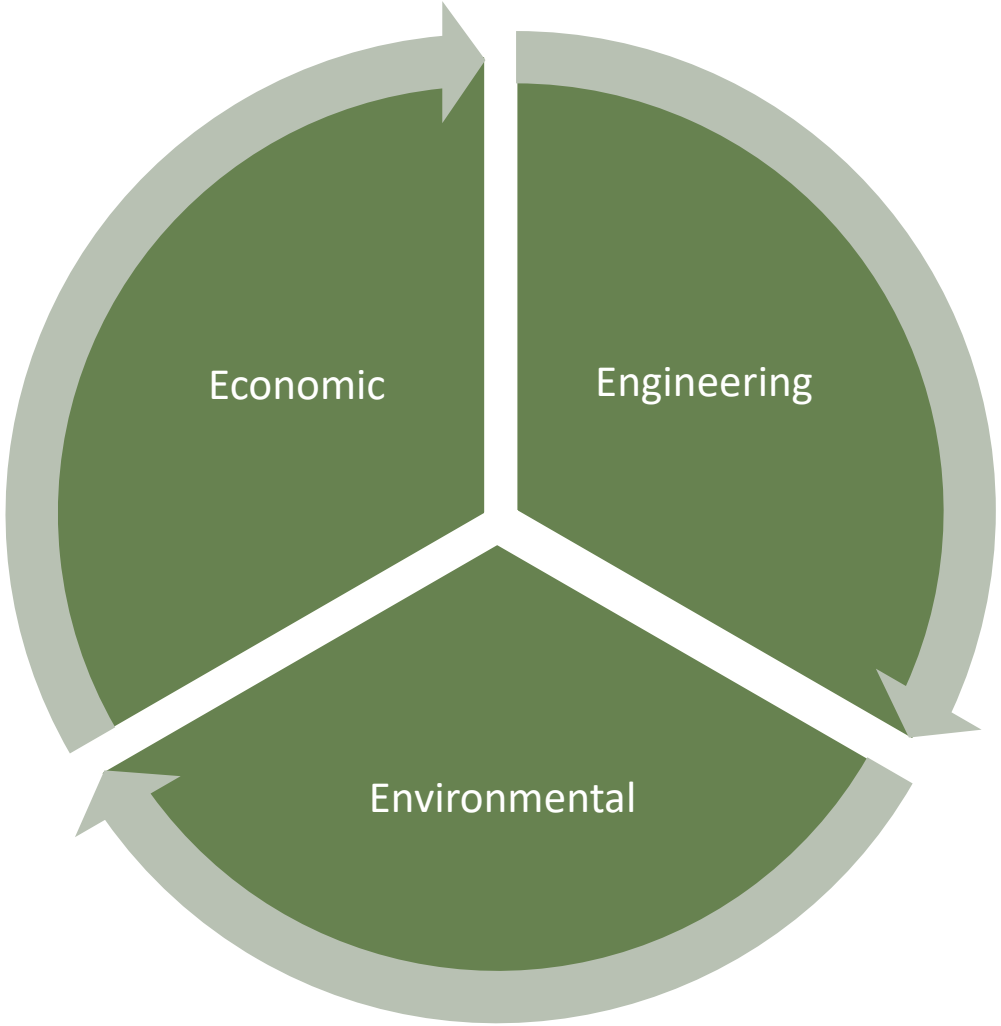
Texas Asphalt Pavement Association

High RAM = Multiple Benefits



All RAM are NOT the Same

Each Materials Combination is UNIQUE

Asphalt Mixtures with High RAM or RBR (NAPA IS138)

MOTIVATION

- US in 2021
  - 432M tons HMA/WMA
  - 21.9% RAP
  - 95M tons RAP,
  - 0.6M tons RAS

- $3.5B = materials savings
  - 1970s/1980s Oil Embargo
  - 1990s/2000s Oil Shock
  - Now ???
- 62M yd^3 landfill space
- 2.6M metric tons CO_2

CONCERN

- Workability
- Compaction

- Performance **w/*Aging***

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RAM = Reclaimed Asphalt Pavement (RAP) + Recycled Asphalt Shingles (RAS)

RBR = Recycled Binder Ratio

$$RBR = \frac{(Pb_{RAP} \times P_{RAP}) + (Pb_{RAS} \times P_{RAS})}{100 \times Pb_{total}}$$

Pb_{RAP}	=	binder content of the RAP
P_{RAP}	=	percentage of RAP by weight of mixture
Pb_{RAS}	=	binder content of the RAS
P_{RAS}	=	percentage of RAS by weight of mixture
Pb_{total}	=	binder content of the combined mixture

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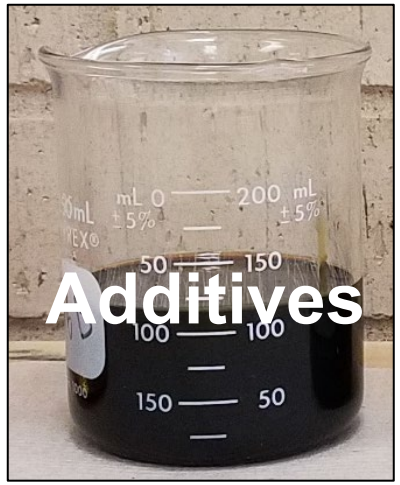
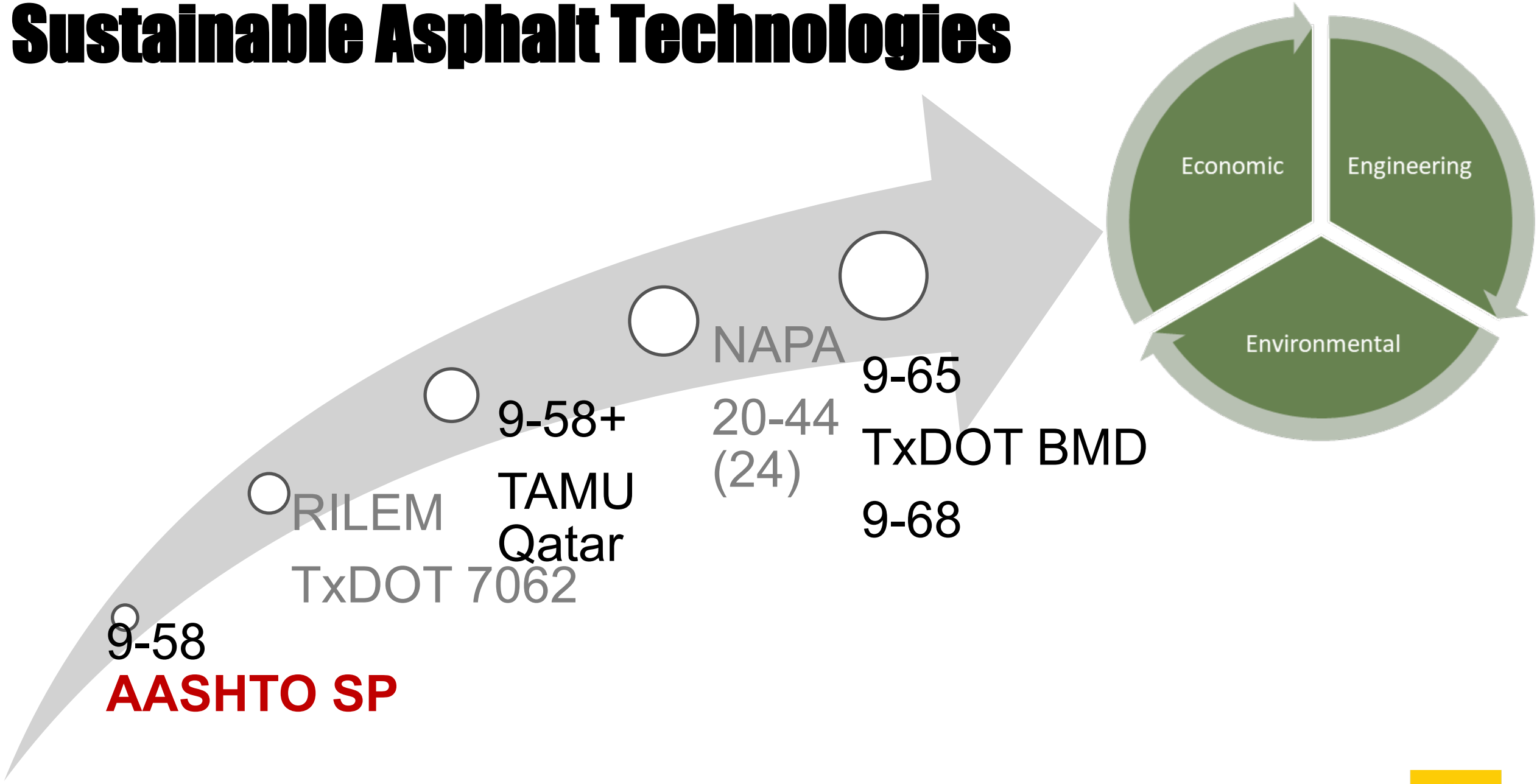
Balanced Mixture Performance is KEY



Sustainable Asphalt Technologies



TxDOT Mixture Types/Specs/Max RAM & RBR @ Surface

Mixture Type	Description	TxDOT Spec	Max RAM	Max RBR
Dense	Traditional Dense-Graded	SS 3076 (Item 341)	15% FRAP 0% RAS	10%
Superpave	Superpave Volumetric	SS 3077 (Item 344)	20% FRAP 0% RAS	15%
Balanced	Superpave Volumetric with Balanced Rutting & Cracking Resistance	SS 3074	35% FRAP 5% RAS	30%
PFC	Permeable Friction Course for Drainage & Noise Reduction	SS 3079 (Item 342)	0%	0%
SMA	Stone-Matrix Asphalt for Rutting Resistance	SS 3080 (Item 346)	20% FRAP 0% RAS	15%
TOM	Thin Overlay Mixture to Restore Skid, Ride with Balanced Rutting & Cracking Resistance	SS 3081 (Item 347)	0%	0%

TxDOT Mix Design Comparison

Mixture Type	Volumetrics	Performance @ 7%AV
Dense (SS 3076)	96% Density VMA_{design}	S_T by IDT, N@12.5 mm RD by HWT, %Stripping by Boil
Superpave (SS 3077)	96% Density, DP VMA_{design}	S_T by IDT, N@12.5 mm RD by HWT, %Stripping by Boil
Balanced (SS 3074)	96% Density, DP VMA_{design}	S_T by IDT, N@12.5mm RD by HWT, *CFE & CPR by OT + CT_{Index} by IDEAL-CT*, %Stripping by Boil
PFC (A_s range) (SS 3079)	78 or 82% Density	%Draindown, %Loss by Cantabro, %Stripping by Boil
SMA (A_s range) (SS 3080)	96%Density VMA_{design}	RD @ 20k by HWT, N by OT, %Draindown, %Stripping by Boil
TOM (min A_s) (SS 3081)	96%Density VMA_{design}	S_T by IDT, N@12.5mmRD by HWT, N by OT, %Draindown

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TxDOT BMD Implementation Effort

- To review, revise, & further develop

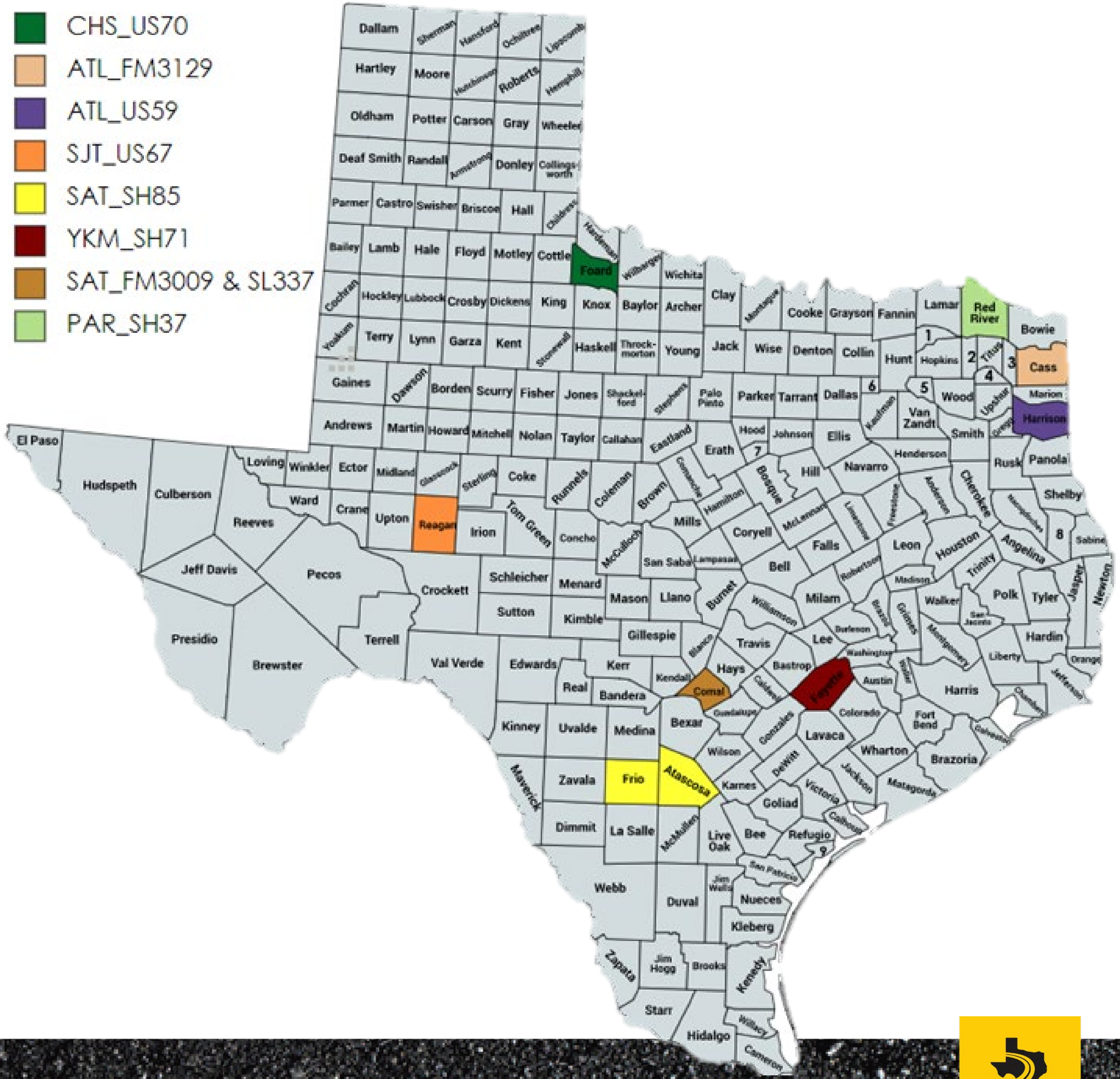
  Superpave BMD for Surface Mixtures with RAP

- Collaboration
  - TxDOT
  - TTI @ Texas A&M
  - CTR @ UT
  - CTIS @ UTEP
  - TxDOT-Industry BMD Working Group
  - Contractors
  - Materials Suppliers

- 9 Field Projects, 33 Test Sections, 96 sublots
  - Varied Climates, Traffic Conditions
  - Focus on Different Mixture Adjustment Factors
- 2019-2022 Complete, 2022-2025 Ongoing

TxDOT BMD 2019-2022 Field Project Locations

- 2019: ATL
- 2020: SAT x2, YKM, ATL
- 2021: PAR, CHS
- 2022: SJT, SAT



TxDOT BMD 2019-2022

FACTORS	#	RAP	RAS	Binder Change	RA	WMA	Agg Qual	Mixture Type(s) & Other Notes
ATL FM3129	3	X	X	X				SP-D (Fine)
SAT SL337	3	X				X	X	SP-C, DG-C Control
SAT FM3009	3	X		X	X	X	X	SP-D, some @ T_{low}
YKM SH71	4	X		X		X	X	SP-D, DG-D, TOM-C Control, some @ T_{low}
ATL US59	4	X		X		X		SP-C, SMA-D Control, some @ T_{low}
PAR SH37	4	X				X		SP-C, DG-C
CHS US 70	3	X		X				DG-D, LAS
SAT SH85(2)	3	X		X	X			SP-C, lime
SJT US 67	6	X		XXX		X	X	SP-C, TR binder, rich RAP

BMD Implementation Effort

produce implementable BMD&A specification that balances engineering performance (rutting, cracking) & provides economic and environmental benefits

Test Projects

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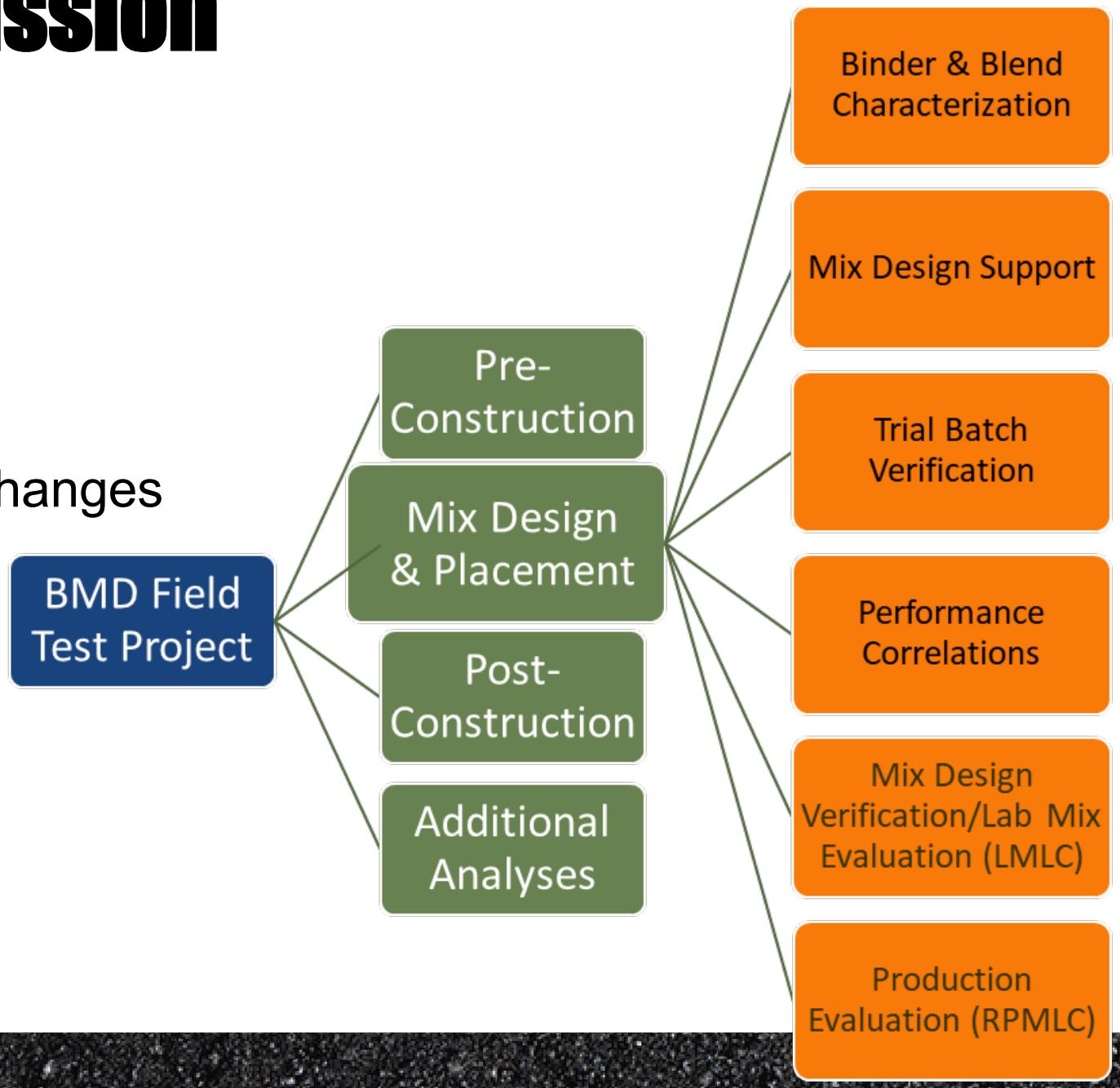
BMD Implementation Effort

produce implementable BMD&A specification that balances engineering performance (rutting, cracking) & provides economic and environmental benefits

Select ≥ 2
Mixture Tests
& Parameters

Concepts for Discussion to Revise SS 3074

- Mix Design
- Trial Batch
- Production Acceptance
- Placement Acceptance-no changes
- Other Items



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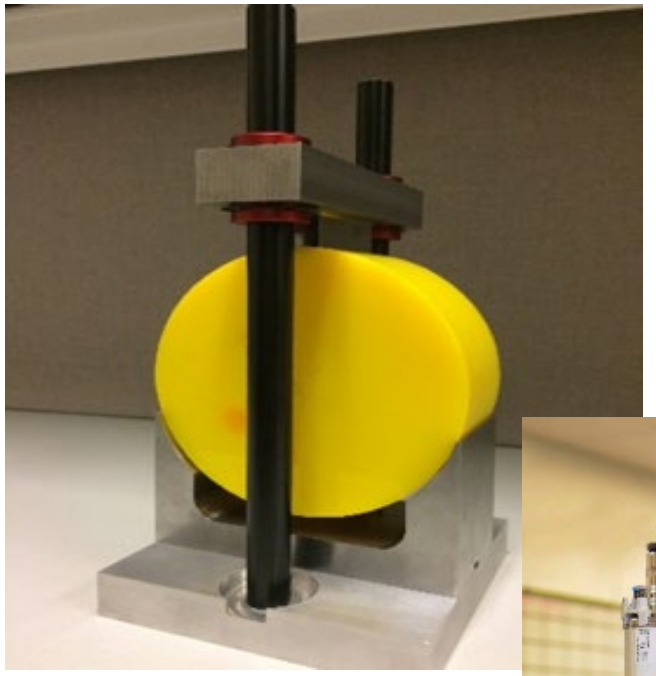
Mixture Testing

- **Rutting**
  - HWT
    - $N_{12.5} \geq$ 10k for PG64
    - $N_{12.5} \geq$ 15k for PG70
    - $N_{12.5} \geq$ 20k for PG76
  - IDEAL-RT
    - $RT_{Index} \geq 60$ for PG64
    - $RT_{Index} \geq 65$ for PG70
    - $RT_{Index} \geq 75$ for PG76
- **Cracking**
  - OT: CPR $\leq$ 0.45 (+ CFE $\geq$ 1.0)
  - IDEAL-CT: $CT_{Index} \geq 80$, ≥ 50 after MTOA
  - S_T: 85-200psi
- **Aging**
  - LMLC: STOA 2hr@T_{comp} [+ MTOA 20hr@95C]
  - RPMLC: Reheat to T_{comp}



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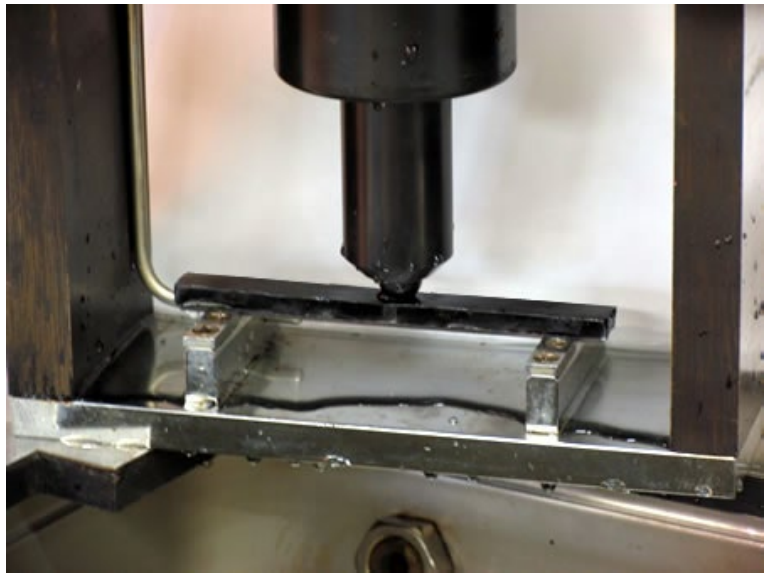
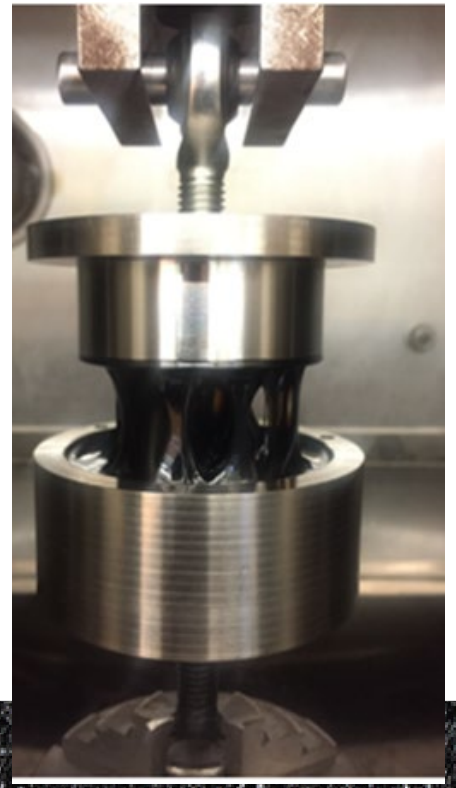
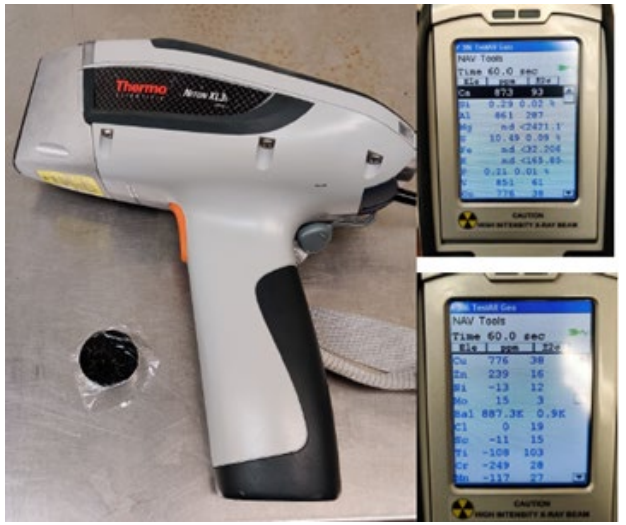
VOLUMETRICS

Binder Testing

- DSR
  - PGH
  - Jnr, %R
  - G-R with aging
- Ductility (Poker Chip) ≥ 150%
- BBR
  - PGL
  - DTc
- FTIR
- XRF
- SARA







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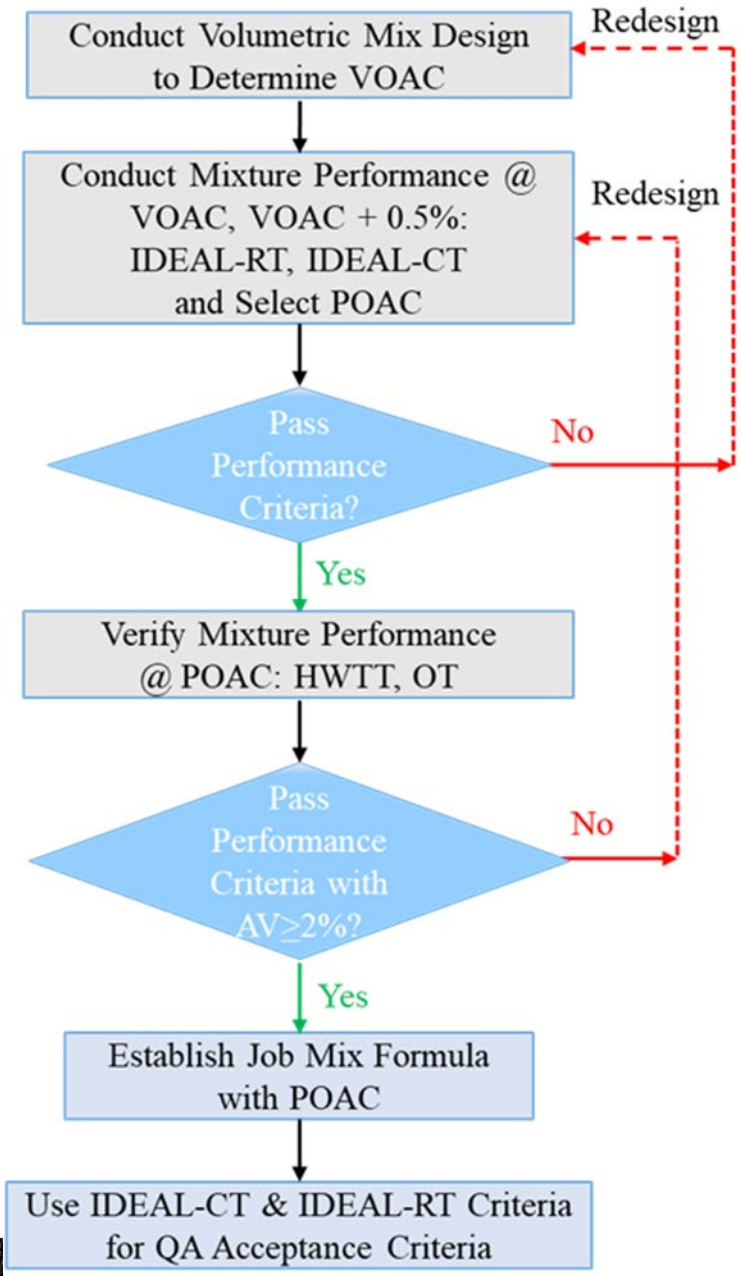
Concepts-Mix Design

- Meet Component Materials & Gradation requirements
- Meet Volumetric requirements
- Conduct IDEAL-RT & IDEAL-CT over range of asphalt binder contents
- Utilize Aging protocol for IDEAL-CT test
- Select (performance) optimum asphalt binder content
- Verify HWT & OT test for compliance
- Establish JMF-1



Concepts-Trial Batch

- Perform IDEAL-RT & IDEAL-CT tests
- Verify HWT & OT tests for compliance? (time constraints)
- Establish JMF-2

Concepts-Operational Tolerances

- Define **operational tolerances** for performance
  - IDEAL-RT and IDEAL-CT
    for Trial Batch/JMF1 and from Current JMF
  - Tighter IDEAL-RT and IDEAL-CT for **Contractor**/**TxDOT**

- **Contractor QC**
  - IDEAL-RT & IDEAL-CT: 4 sublots per lot with n=1? RT and n=3? CT tests per sublot
  - HWTT & OT only if RT or CT fall below threshold
- **TxDOT**
  - Accept contractor results OR

  IDEAL-RT & IDEAL-CT: 1 sample per 5 lots (random) with n=1? RT and n=3? CT tests each
  - HWTT & OT only if RT or CT fall below threshold

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Concepts-Other Items

Component Materials

- Allow use of unmodified softer asphalt binders
- Allow aggregate gradation above restricted zone
- Include PC ductility

Proportions

- Allow use of Higher RAP contents ≥ 35% (≥ 30% RBR)
- Add 75% RAM binder availability for high RAM (>20% RBR)

Mix Design & Performance

- Include IDEAL-RT test
- Require 50 gyrations only
- Relax IDT requirement
- Revise Moisture Sensitivity evaluation - HWTT presently used
- Remove minimum HWTT requirement

Concepts-Other Items

Acceptance

- Revise acceptance criteria - future
- Require frequent ignition oven correlation - within 2 months of project

Other

- Consider RAP QMP
- Develop BMD with High RAP GUIDE
- Consider CT requirements by climate – future
- Relax volumetric requirements

  (toward BMD approach D) – future

Tiered Approach (NAPA QIP 131)

Approach	Field Performance Risk	Mix Design Risk	Time and Equipment Needs	Cost	Binder Evaluation			Mixture Evaluation	
					Virgin	RAP and/or RAS	Blend	Rutting	Cracking
Simplest	Mod	High	Low	Low	No	No	No	Yes	Yes
Intermediate	Mod	Mod	Mod	Mod	Yes	Yes	No	Yes	Yes
Comprehensive	Low	Low	High	High	Yes	Yes	Yes	Yes	Yes

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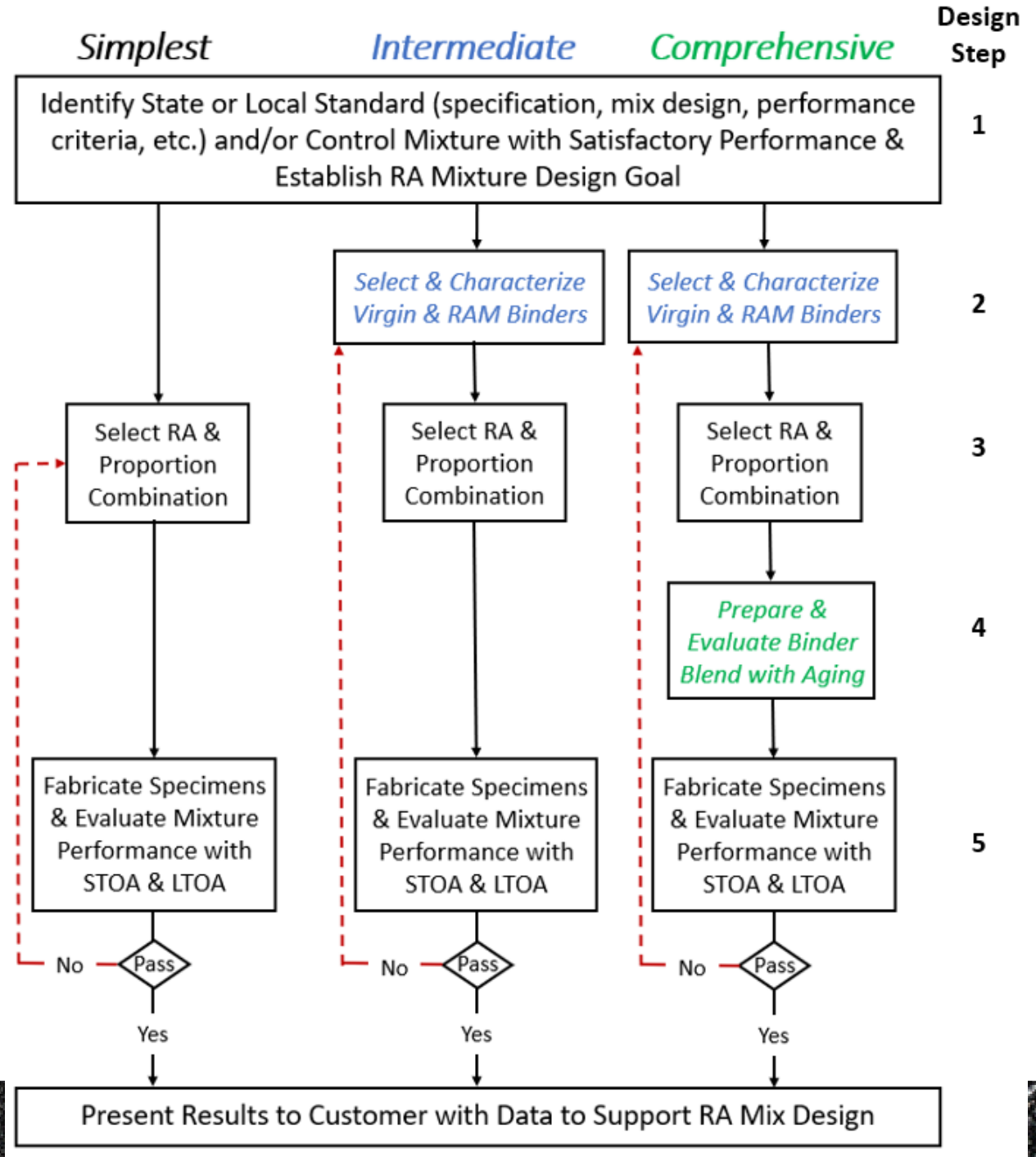
Tiered Approach



Balanced Mix Design with High RAM

- **Volumetrics**
  - Consider effects of absorbed binder
    - VMA = AV + V_{be} = f(G_{sb})
    - DP = p_{200} / P_{be}
  - Decrease recycled binder availability
  - Increase effective binder
    - Increase OBC, VMA
    - Add RA
    - Specify min OBC
    - Decrease design AV
    - Reduce N

- **Strategies for BMD**
  - Increase RA dose or Change type
  - Select softer virgin binder or one with better ΔT_c
  - Adjust aggregate blend
  - Modify split between RAP_{BR} and RAS_{BR} or reduce RAS_{BR}
  - Reduce overall RAM or RBR

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Mix Design Example – Simplest Approach

Mixture Properties	Control Mixture 0.0 RBR	RAM Mixture 0.33 RBR	Evaluation Criteria
Proportioning & Materials Selection			
NMAS	½"	½"	½"
Virgin Binder PG	PG 64-28 PM	PG 64-28 PM	PG 64-28 PM
OBC (%)	5.5	5.6	Not specified
RAP Content (%)	0	40	Not specified
RAS Content (%)	0	0	Not specified
RBR	0	0.33	Not specified
Recycling Agent Type	n/a	Bio-based	Not specified
Recycling Agent Dose (% by wt total binder)	0.0	4.0	Not specified
Mixture			
HWTT RD (mm) @ 50°C	3.9	3.5	≤ 12.5mm @ 20,000 cycles
IDEAL-CT CT_{Index} @ 25°C	85	90	≥ Control Mixture

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Mix Design Example – Intermediate/Comprehensive Approaches

Mixture Properties	Virgin 0.0 RBR	DOT Control 0.22 RBR	Recycled 0.31 RBR	Recycled w/Softer Binder 0.31 RBR	Rejuvenated 0.31 RBR	Evaluation Criteria
Proportioning & Materials Selection						
NMAS	½"	½"	½"	½"	½"	Not specified
Virgin Binder PG	PG 58-28	PG 58-28	PG 58-28	PG 52-34	PG 58-28	PG 58-28 for climate & traffic
OBC (%)	5.6	5.6	5.4	5.4	5.4	Not specified
RAP Content (%)	0	27	36	36	36	Not specified
RAS Content (%)	0	0	0	0	0	Not specified
RBR	0	0.22	0.31	0.31	0.31	Not specified
Recycling Agent Type	n/a	n/a	n/a	n/a	Bio-based	Not specified
Recycling Agent Dose (% by wt total binder)	0.0	0.0	0.0	0.0	5.5	Not specified

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Mix Design Example – Intermediate/Comprehensive Approaches

Mixture Properties	Virgin 0.0 RBR	DOT Control 0.22 RBR	Recycled 0.31 RBR	Recycled w/Softer Binder 0.31 RBR	Rejuvenated 0.31 RBR	Evaluation Criteria
Component Materials						
Virgin Binder PGH (°C)	59.4	59.4	59.4	52.3	59.4	Not specified
Virgin Binder ΔT_c (°C)	-3.4	-3.4	-3.4	+0.4	-3.4	$\geq$ -3.5°C
RAP Binder PG	n/a	PG 82-10	PG 82-10	PG 82-10	PG 82-10	Not specified
RAP Binder PGH (°C)	n/a	83.5	83.5	83.5	83.5	Not specified
RAP Binder ΔT_c (°C)	n/a	-7.3	-7.3	-7.3	-7.3	$\geq$ -7.5°C
Binder Blend						
Binder Blend Continuous PG	n/a	PG 65-25	PG 68-23	PG 62-26	PG 59-33	PG 58-28
Binder Blend ΔT_c (°C)	n/a	-4.3	-5.3	-2.9	-3.1	$\geq$ -5.0°C
Mixture						
HWTT $N_{12.5}$ @ 50°C	NA	NA	NA	NA	6750	$\geq$ 5,000
I-FIT FI @ 25°C	12	14	10	17	16	$\geq$ 7
UTSST CRI_{Env}	NA	23	8	22	57	$\geq$ 17

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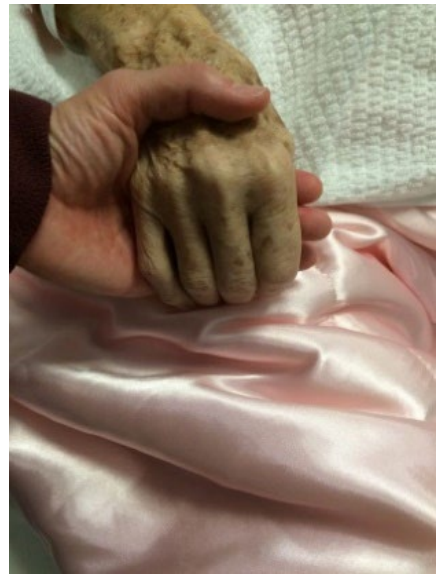
Draft AASHTO Standard Practice for Engineering High RBR (0.3-0.5) Recycled Mixtures

- Component Materials Selection & Proportioning Guidelines with Recycling Agent Dose Selection Method



- Binder Blend Rheological Evaluation Tools
- Mixture Performance Evaluation Tools
- RAP Binder Availability Factor

TX BMD with High RAP GUIDE

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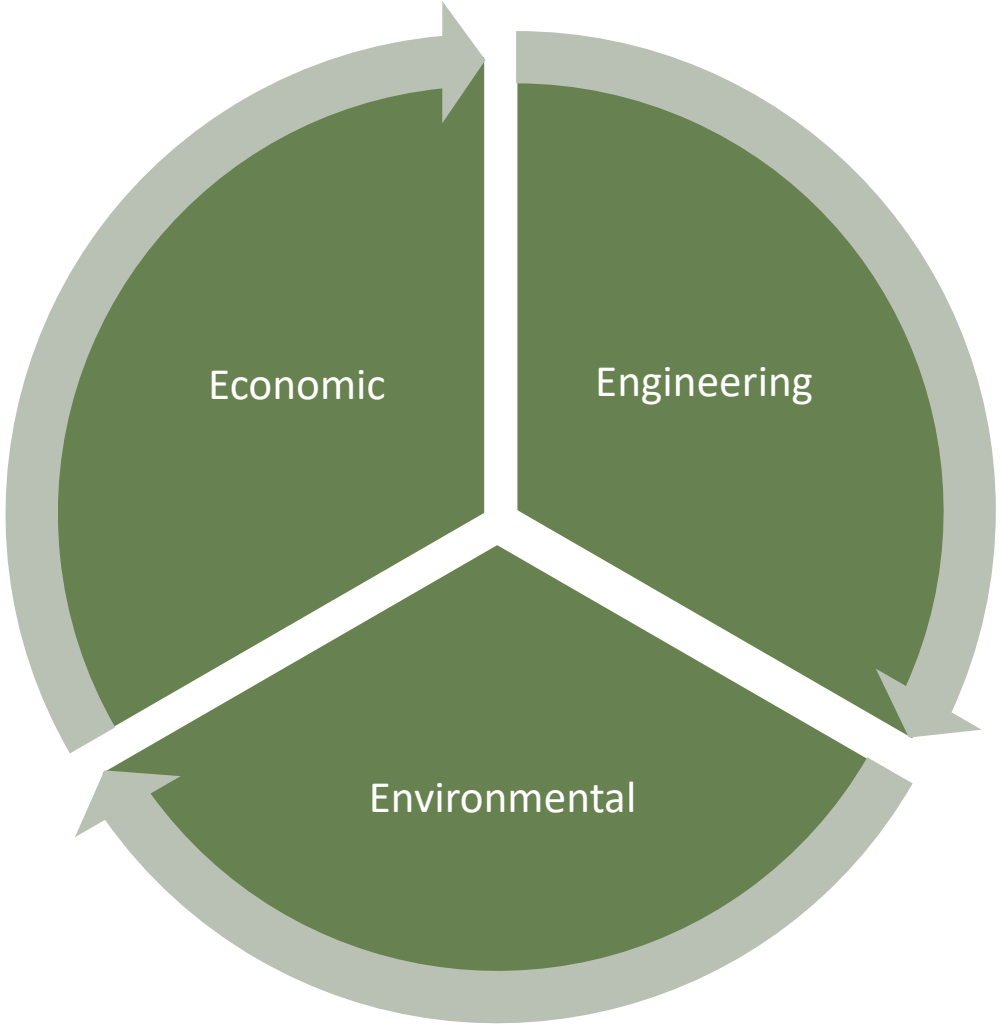

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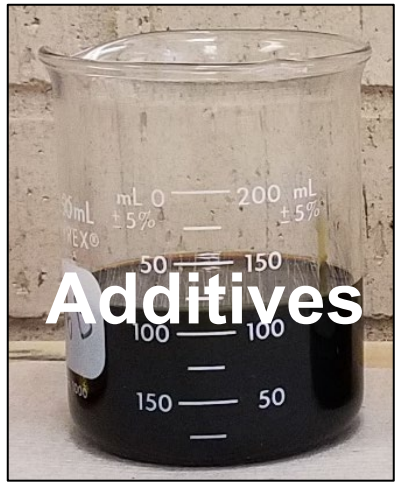

Questions & Discussion