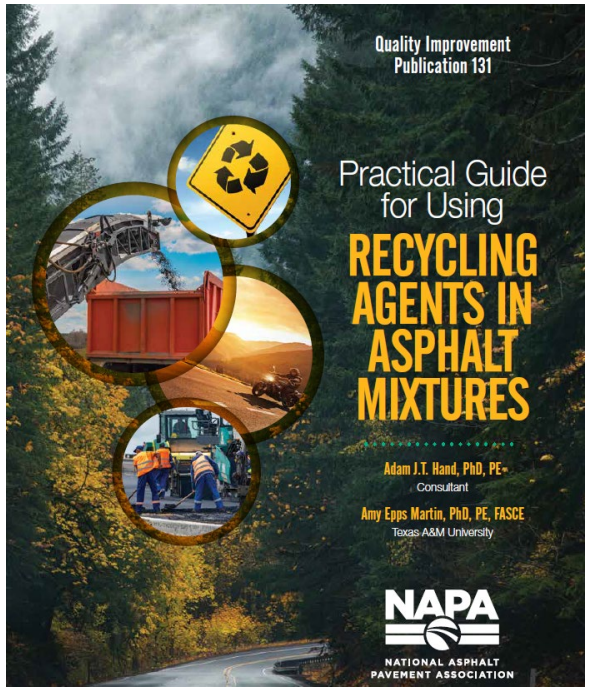
Recycling Agents – What to Know

Adam Hand, PE, PhD
University of Nevada

ASPHALT KEEPS MICHIGAN MOVING!

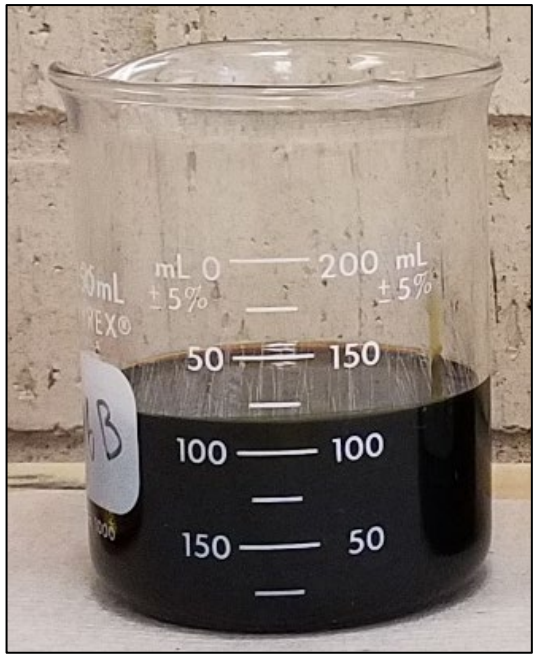
ACKNOWLEDGEMENTS

- NAPA: QIP-131 Development
  - Brett Williams & Richard Willis
- NAPA Members
  - Panel & Examples
- Amy Epps Martin
  - Co-Author



OUTLINE

- Introduction
- Recycling Agents (RA)
- Mix Design Using Recycling Agents with Examples
- Practical Consideration when Producing & Placing Mixtures with RAs
- Summary
- Q&A

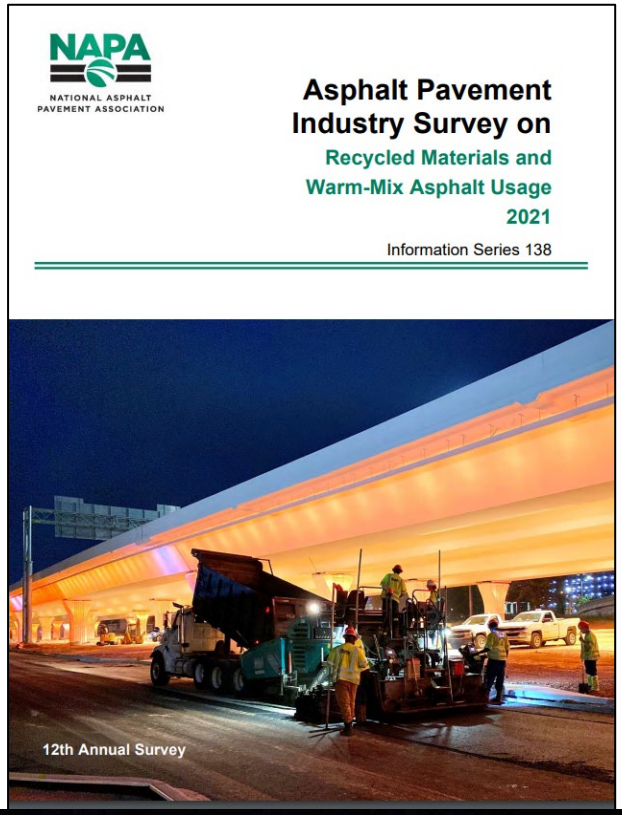


OBJECTIVE

- Background – *"What and Why"*
- Provide Tiered Mix Design Approaches to Facilitate Use of RAs in Asphalt Mix to Produce Good Performing Pavements – the *"How"*
- Focus on:
  - Tier Mix Design Approach Consistent with BMD using Examples
  - Practical Production Considerations
- Have Q&A

INTRODUCTION/BACKGROUND

- Asphalt Industry is Sustainability Leader
  - $3.7B Virgin Binder and Aggregate Savings
- Recycling & RA Focus
  - 1970's & 1980's Oil Embargoes: RAs Introduced
  - Late 2000's Binder Cost Increase: RAM use Increased
  - Early 2010's High RAM Durability Challenges & Solutions
    - Adequate and Softer PG Virgin Binders
    - Recycling Agents
- Primary RA Uses
  - Meet BMD Durability Requirements at Current RAM Level
  - Increase RAM Level, Other Benefits
- Economics of Increasing RAM *Very* Market Dependent
  - Urban vs. Rural, Specifications, S&D Commodity Prices, …
  - Every Situation is Unique



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RECYCLED MATERIALS – RAP, RAS, GTR, PLASTICS, CARBON BLACK, …

- RAP

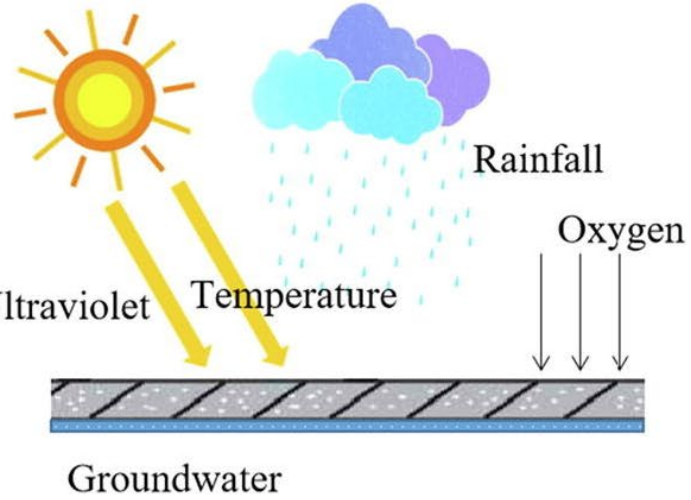
- RAS

RECYCLING AGENTS

- Terminc
  - Soft
  - Reju
  - Not
- Basic Ty
  - Petr
  - Bio-
  - Not
- Import
  - Seve
    Engi
- Some F
- For Cor
  - RA [
    -
  - RBR
    -
    - Future ≤ 0.30, 0.65, 100?

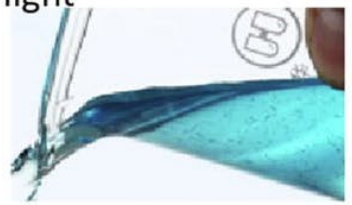
Aging Process

Virgin unaged asphalt



Asphalt aging

Supplement of light components



Dissolution and dilution

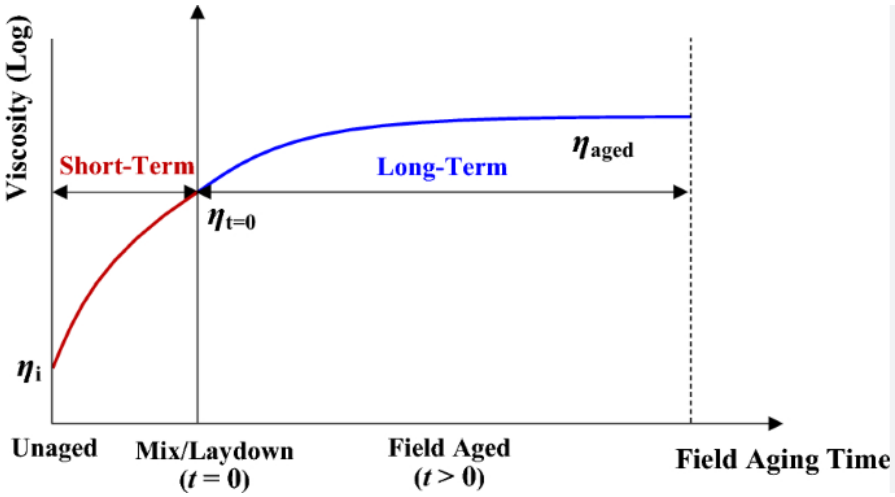
Rejuvenator

Rejuvenation of aged asphalt

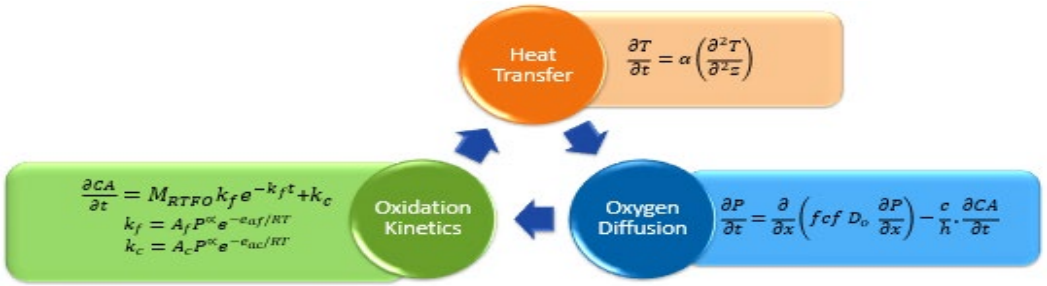
Guo, et.al
https://doi.org/10.1016/j.conbuildmat.2021.124077

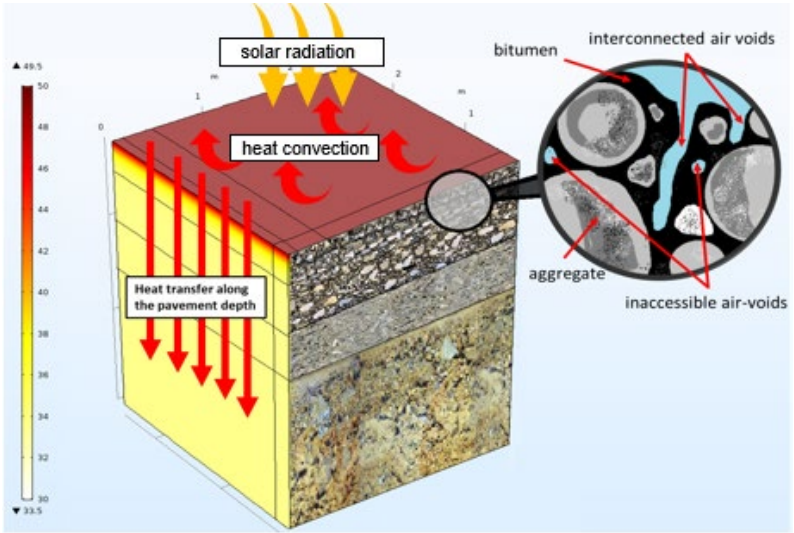
AGING PROCESS

- Mixture Aging Process
  - Short-Term: Volitization & Oxidative Aging
  - Long-Term: Oxidative Aging



Zhang, D. (et.al, 2019)
https://link.springer.com/article/10.1617/s11527-019-1364-7



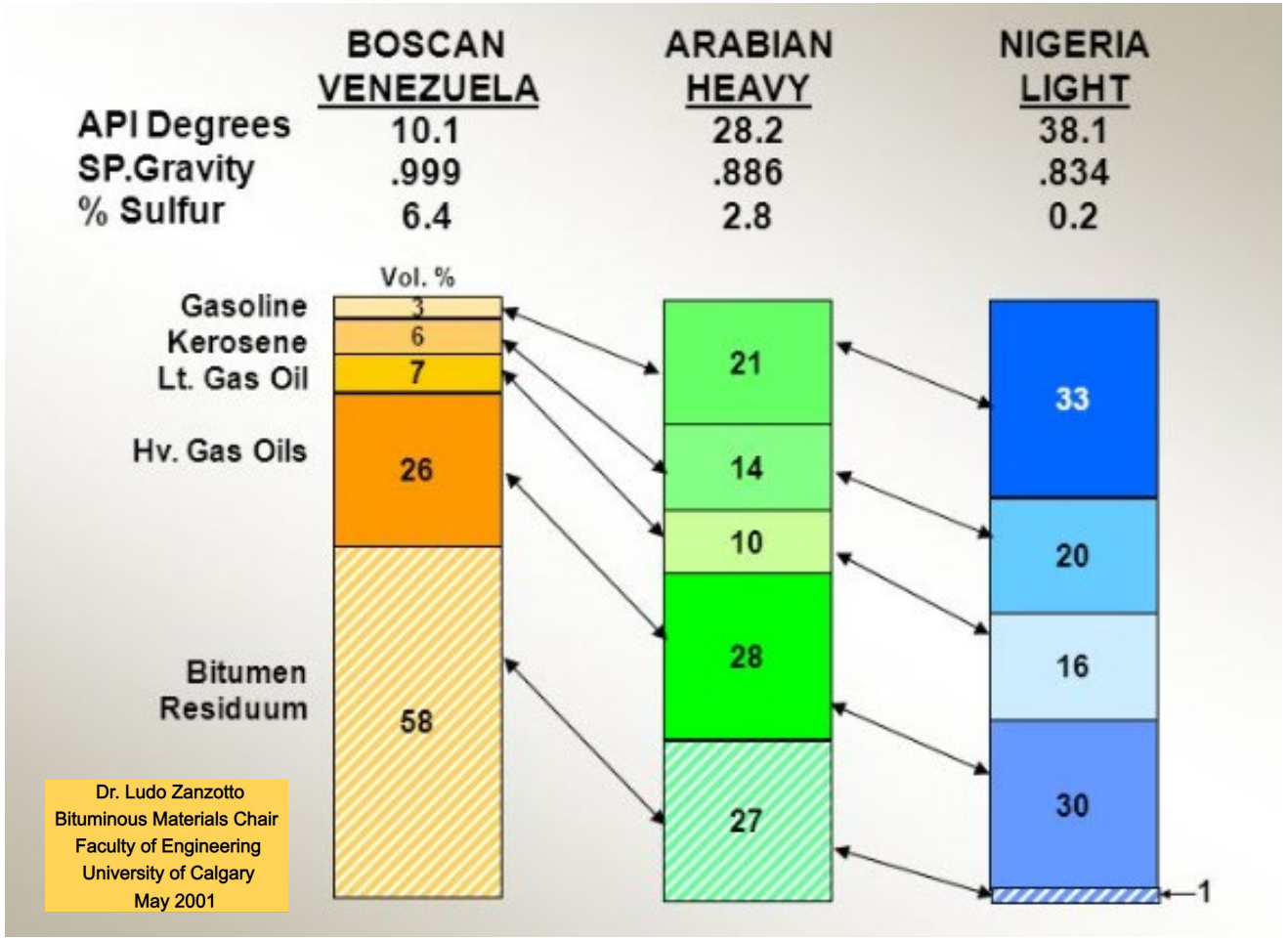


E. Omairey (et.al, 2019)
https://www.comsol.com/paper/multiphysics-simulation-and-validation-of-field-aging-of-asphalt-pavements-83241

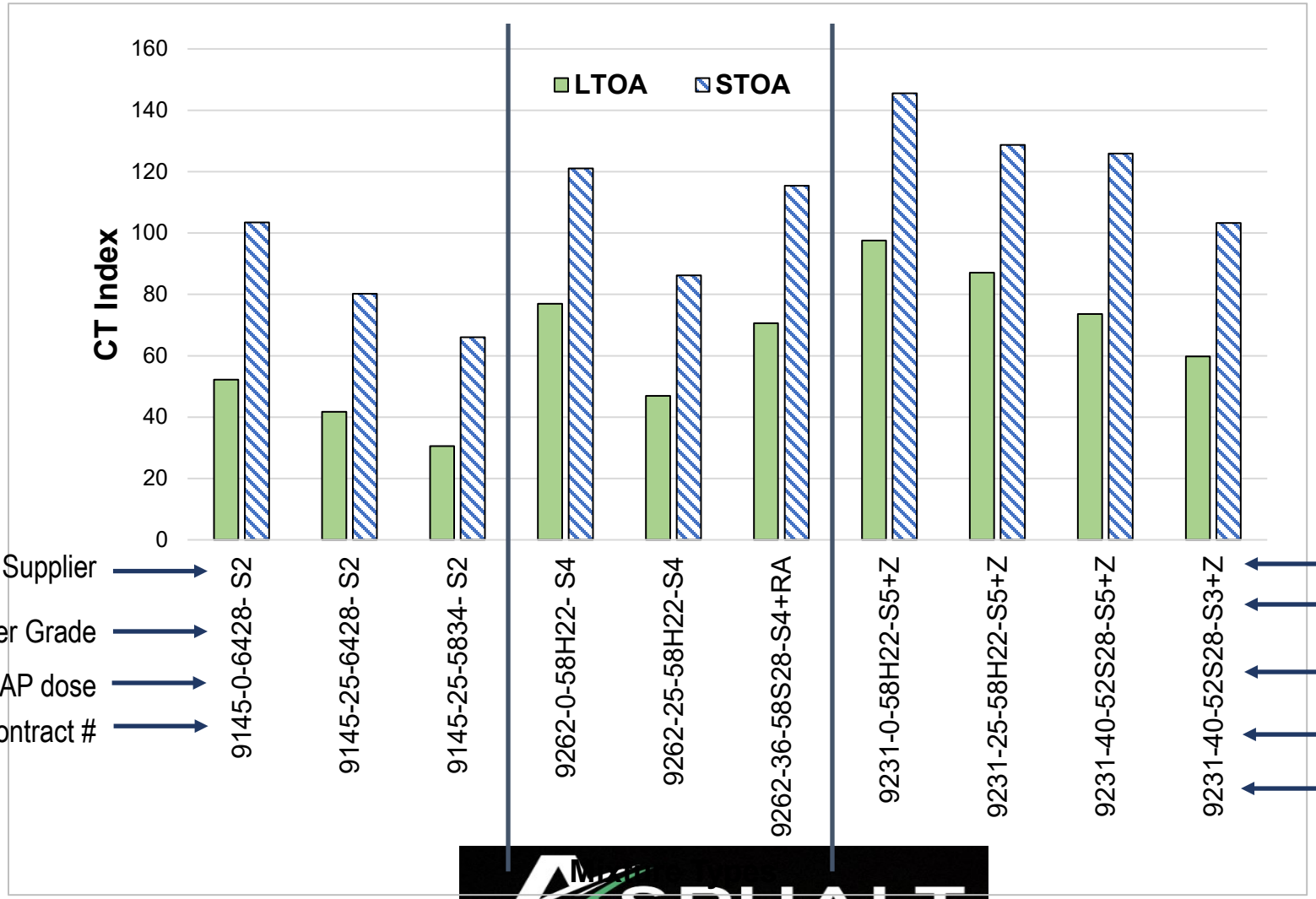
CRUDE OIL SOURCE MATTERS

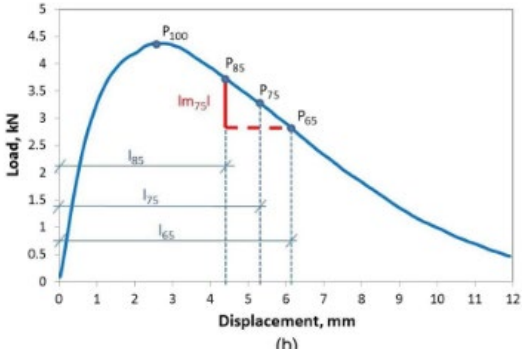
- **Bitumen Yields Vary**
  - **Chemical Compositions Vary**
- **Asphalt Binders w/in PG Vary**
  - **Base Asphalt Source/Chemistry**
  - **Blending Stocks**

- *Binders Vary….*
- *Binder Rheological <u>Behavior</u> Varies & Changes with Aging*



SAME SOURCE – GRADE BUMPING DOWN & RECYCLING AGENTS





CLASSIFICATION OF RECYCLING AGENTS

Lectern Session 1130

1130 - Recycling Agent Classification and Categorization

Texas A&M's new recycling agent classification system
Amy Epps Martin, Texas A&M University, College Station

ASTM D4552 classification system
Sebastian Puchalski, Kraton Polymers
Hassan Tabatabaee, Cargill, Inc.

NCAT classification study for bio-based rejuvenators
Raquel Moraes Puchalski, National Center for Asphalt Technology (NCAT)

Nebraska's classification study based on raw materials source
Hamzeh Haghshenas, University of Nebraska, Lincoln

- Asphaltenes
- Saturates
- Aromatics
- Resins

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CLASSIFICATION OF RECYCLING AGENTS

- ASTM D4552 (2019/2020)
- Bio-oils integrated

TABLE 1 Physical Properties of Hot-Mix Recycling Agents

Test	ASTM Test Method	RA 0 Min	RA 0 Max	RA 1 Min	RA 1 Max	RA 5 Min	RA 5 Max	RA 25 Min	RA 25 Max	RA 75 Min	RA 75 Max	RA 250 Min	RA 250 Max	RA 500 Min	RA 500 Max
Viscosity - 60 °C [140 °F], mm^2/s	D2170/D2170M	10	49	50	175	176	900	901	4500	4501	12 500	12 501	37 500	37 501	60 000
Flash Point, COC, °C [°F]	D92	219 [425]	...	219 [425]	...	219 [425]	...	219 [425]	...	219 [425]	...	219 [425]	...	219 [425]	...
Saturates, wt, %[A]	D2007	...	30	...	30	...	30	...	30	...	30	...	30	...	30
Tests on Residue from RTFO 163 °C [325 °F]	D2872														
Viscosity Ratio[B]	D2872	...	3	...	3	...	3	...	3	...	3	...	3	...	3
Wt Change, ±, %	D2872	...	4	...	4	...	4	...	4	...	4	...	4	...	4
Specific Gravity at 25 °C [77 °F]	D70 or D1298	0.900	1.100	0.900	1.100	0.900	1.100	0.900	1.100	0.900	1.100	0.900	1.100	0.900	1.100

Most Bio-oils

Most Petro. oils

D4552/D455

How can D4552 be used in Specs? Example:

Step 0 — Check if RA meets basic safety / physical requirements → ASTM D4552-20

Step 1 — Establish dosage and check rejuvenated binder properties *(e.g. change in ΔTc with aging)*

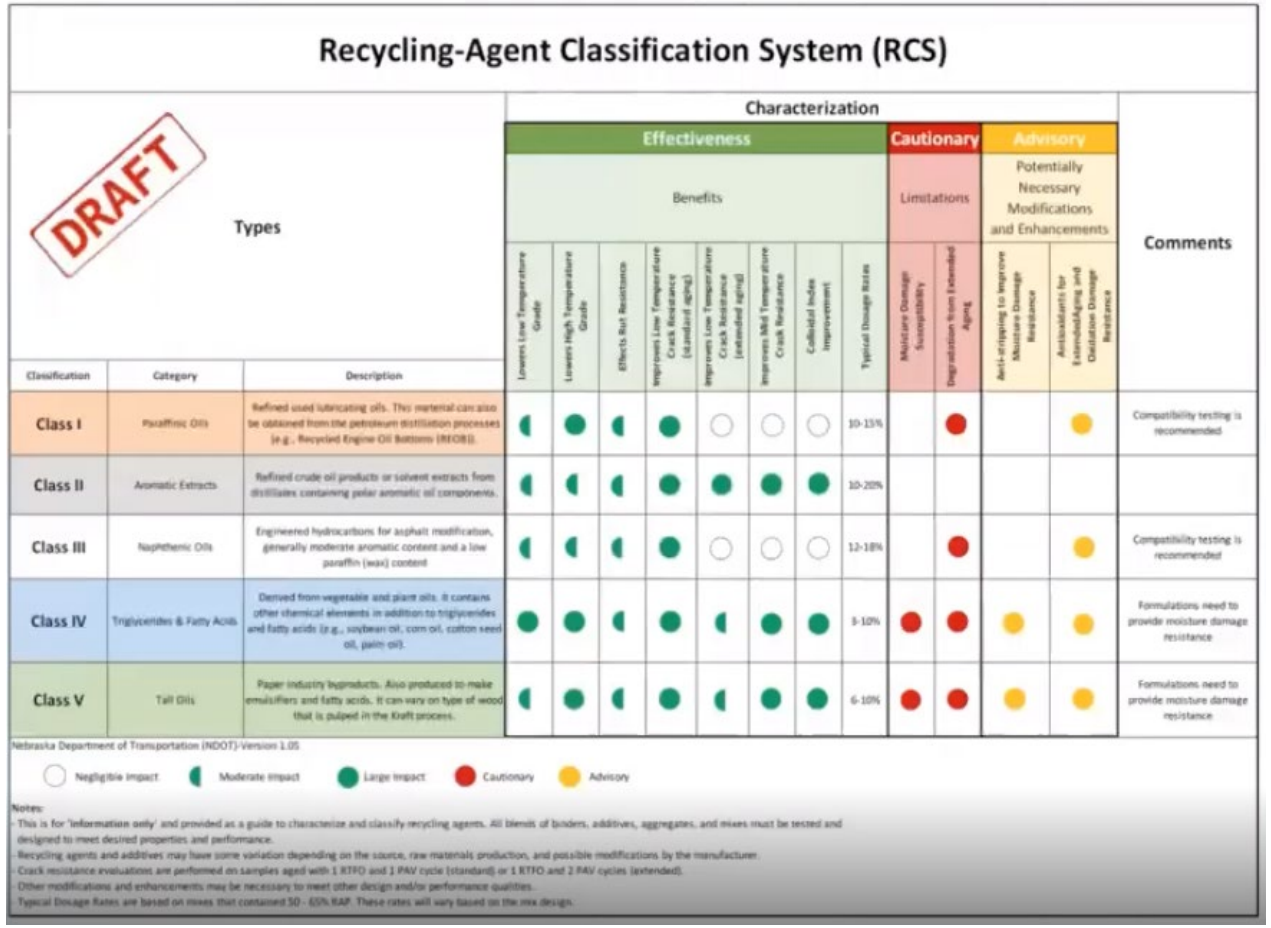
Step 2 — Perform Balanced Mix Design *(iterate with step 1 as needed to meet performance.)* → NCHRP 9-58 or NAPA RA Guide

CLASSIFICATION OF RECYCLING AGENTS

- TTI 2 New Classification Parameters
  - Binder Embrittlement Parameter (BEP) = identifies oxidation and rheological stiffening of RA
  - Rejuvenation Index (RI) = identifies aging resistance and inhomogeneity of RA
- TTI 3 New RA Classifications
  - P (paraffinic oil) = only SOFTENER with poor compatibility and aging sensitivity (no Polar compounds)
  - A (aromatic extract-petroleum based) = sufficient REPLENISHER for some binder blends at high doses (polar aromatics)
  - V&B (vegetable & bio oils) = EMULSIFIER to compatabilize, oxidize but less rheological effect
  - T (tall oils) = EMULSIFIER that is more sensitive to aging/more volatile

CLASSIFICATION OF RECYCLING AGENTS

- Nebraska DOT
  - UNL Research
- 5 Classes
  - Class I: Paraffinic Oils
  - Class II: Aromatic Extracts
  - Class III: Napthenic Oils
  - Class IV: Triglycerides & Fatty Acids
  - Class V: Tall Oils



Recycling-Agent Classification System (RCS)

DRAFT

Classification	Category	Description	Effectiveness: Benefits: Lowers Low Temperature Grade	Lowers High Temperature Grade	Effects Rut Resistance	Improves Low Temperature Crack Resistance (standard aging)	Improves Low Temperature Crack Resistance (extended aging)	Improves Mid Temperature Crack Resistance	Colloidal Index Improvement	Typical Dosage Rates	Cautionary: Limitations: Moisture Damage Susceptibility	Degradation from Extended Aging	Advisory: Potentially Necessary Modifications and Enhancements: Anti-stripping to Improve Moisture Damage Resistance	Antioxidants for Extended Aging and Oxidation Damage Resistance	Comments
Class I	Paraffinic Oils	Refined used lubricating oils. This material can also be obtained from the petroleum distillation processes (e.g., Recycled Engine Oil Bottoms (REOB)).	◖	●	◖	●	○	○	○	10-15%		●		●	Compatibility testing is recommended
Class II	Aromatic Extracts	Refined crude oil products or solvent extracts from distillates containing polar aromatic oil components.	◖	◖	◖	●	●	●	●	10-20%					
Class III	Napthenic Oils	Engineered hydrocarbons for asphalt modification, generally moderate aromatic content and a low paraffin (wax) content	◖	◖	◖	●	○	○	○	12-18%		●		●	Compatibility testing is recommended
Class IV	Triglycerides & Fatty Acids	Derived from vegetable and plant oils. It contains other chemical elements in addition to triglycerides and fatty acids (e.g., soybean oil, corn oil, cotton seed oil, palm oil).	●	●	◖	●	◖	●	●	3-10%	●	●	●	●	Formulations need to provide moisture damage resistance
Class V	Tall Oils	Paper industry byproducts. Also produced to make emulsifiers and fatty acids. It can vary on type of wood that is pulped in the Kraft process.	◖	●	◖	●	◖	●	●	6-10%	●	●	●	●	Formulations need to provide moisture damage resistance

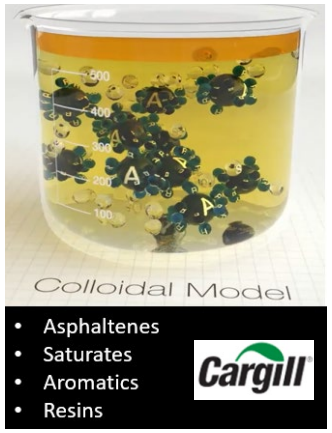
Nebraska Department of Transportation (NDOT)-Version 1.05

○ Negligible Impact ◖ Moderate Impact ● Large Impact ● Cautionary ● Advisory

Notes:
- This is for 'information only' and provided as a guide to characterize and classify recycling agents. All blends of binders, additives, aggregates, and mixes must be tested and designed to meet desired properties and performance.
- Recycling agents and additives may have some variation depending on the source, raw materials production, and possible modifications by the manufacturer.
- Crack resistance evaluations are performed on samples aged with 1 RTFO and 1 PAV cycle (standard) or 1 RTFO and 2 PAV cycles (extended).
- Other modifications and enhancements may be necessary to meet other design and/or performance qualities.
- Typical Dosage Rates are based on mixes that contained 30 - 65% RAP. These rates will vary based on the mix design.

RECYCLING AGENTS

- Many Available
- Different Compositions
- Different Impacts
- Different Aging
- …



Cargill

Anova®

COLLABORATIVE AGGREGATES LLC

Delta S

ENGINEERED ADDITIVES LLC

HYDROGREEN®

ingevity

EVOFLEX™

SRIPATH TECHNOLOGIES, LLC
Make Asphalt Better.

RELIXER

POET

JIVE

Road Science™
Division of ArrMaz

ARKEMA | ArrMaz
BUILDING A NEW LEADER IN SPECIALTY SURFACTANTS

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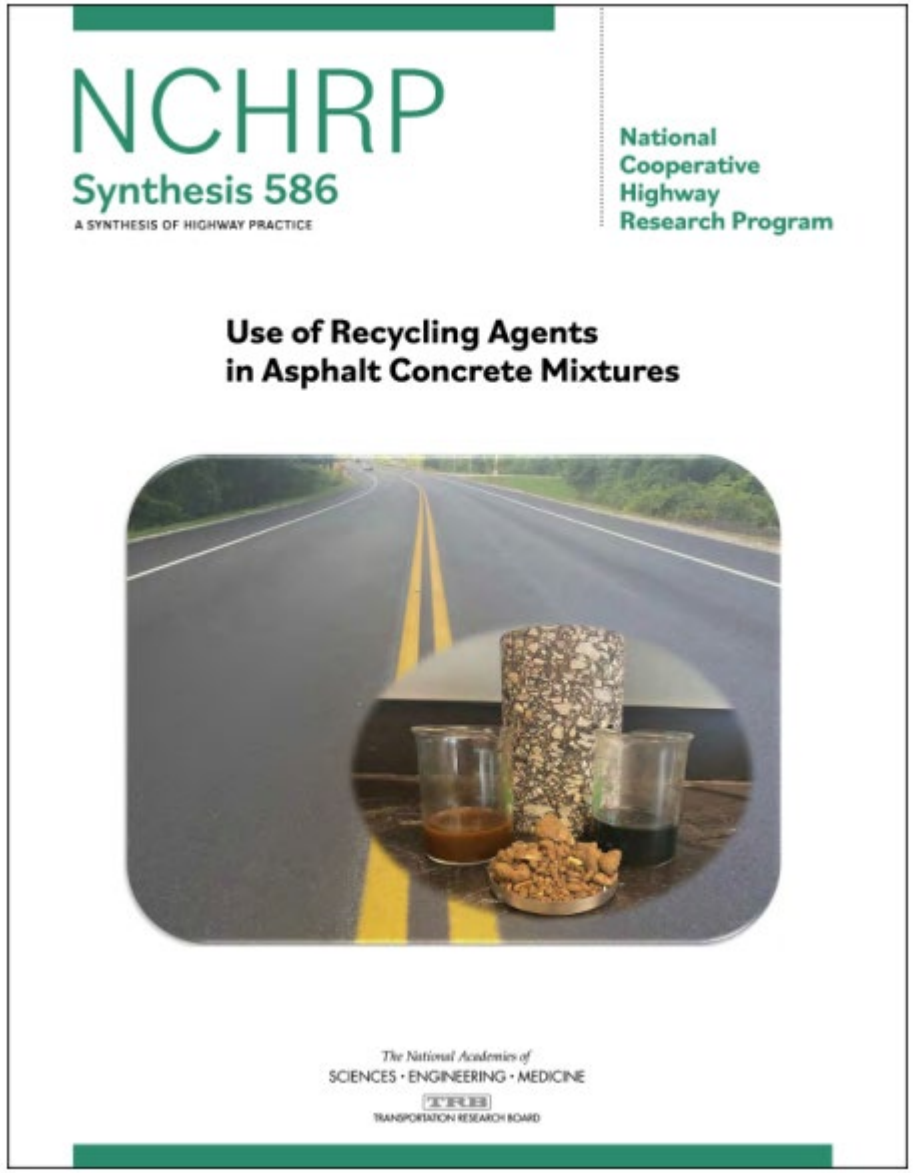
NCHRP SYNTHESIS 586

- **Use of Recycling Agents in Asphalt Concrete Mixtures**

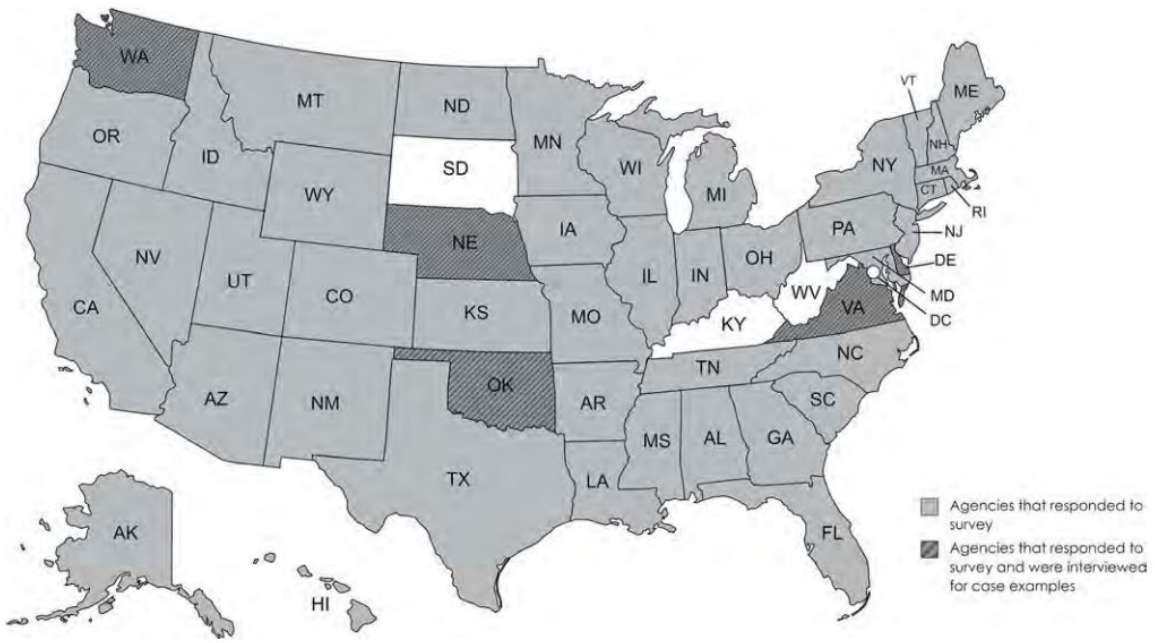
- *Objective of this synthesis is to document current state DOT practices and procedures related to the use of RAs in asphalt mixtures containing RAM.*



https://nap.nationalacademies.org/download/26601

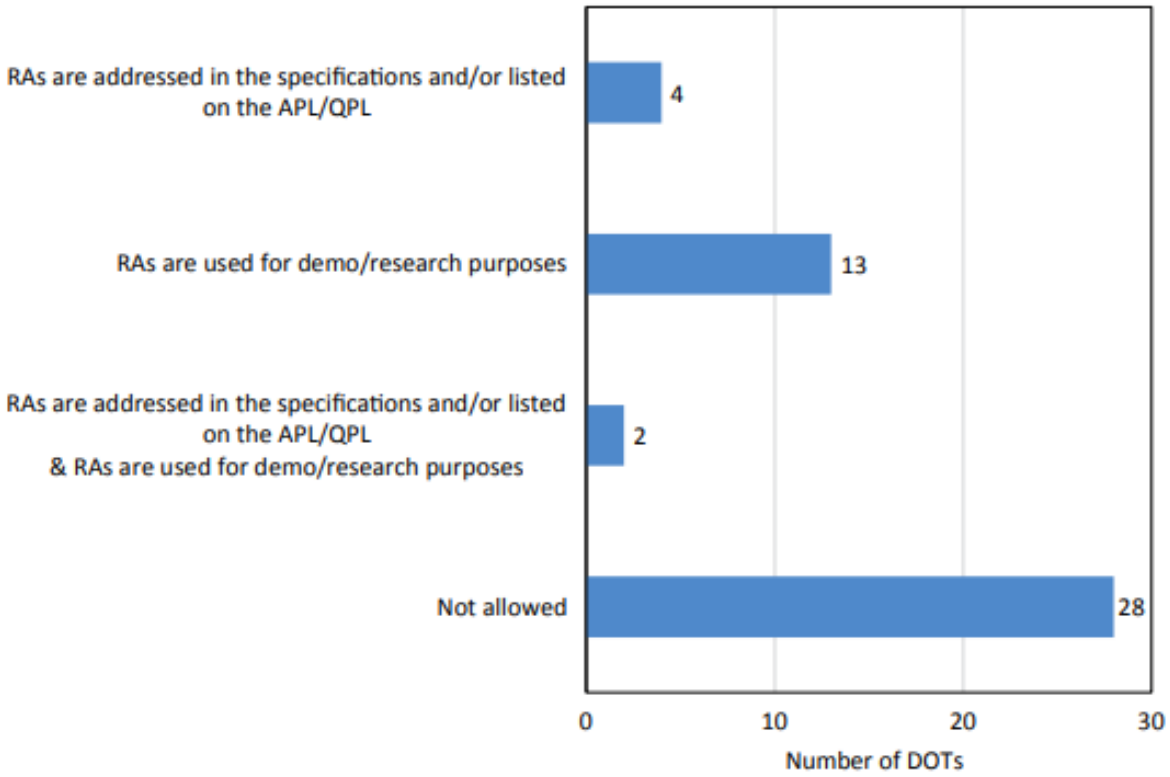
NCHRP SYNTHESIS 586 - RESPONDENTS

USA



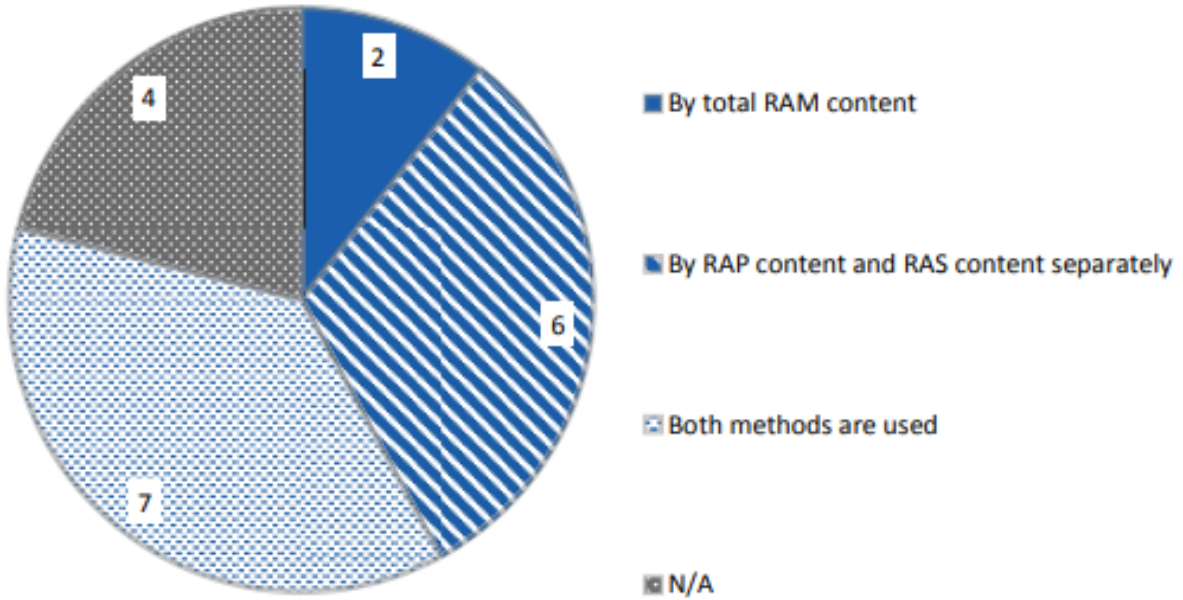
Canada

NCHRP SYNTHESIS 586



Note: Number of responses = 47.

Figure 5. Distribution of responding state DOTs with respect to usage of RAs in asphalt mixtures.

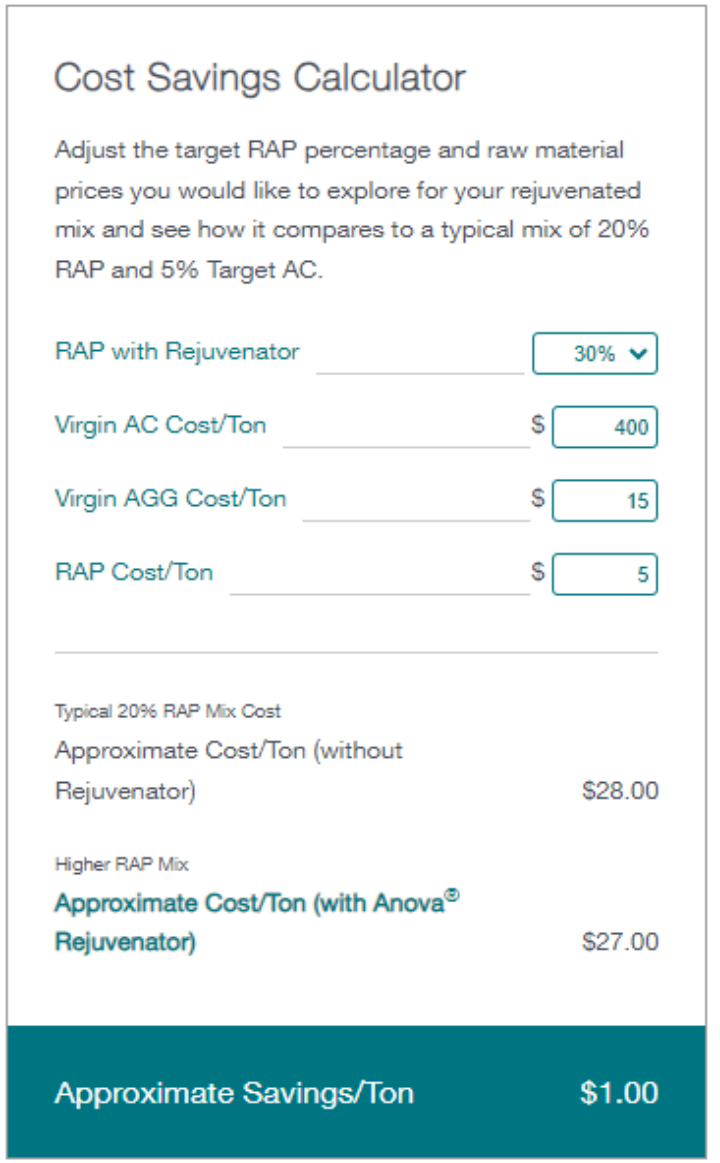


Notes: N/A = question not answered; number of responses = 19.

Figure 7. Distribution of responding state DOTs that allow use of RAs on specification of RAM content in asphalt mixtures.

RECYCLING AGENT ECONOMICS

- Know Your Costs
  - Materials
  - Production
- Evaluate Performance with RA's
  - STOA & LTOA
- Evaluate the Economics of RA's
- What are differences?
  - Introduced at the Terminal vs. Plant
  - Higher RAP percentages (moisture mgmt.)
  - ….



https://www.cargill.com/bioindustrial/anova/asphalt-rejuvenators

MIX DESIGN


RAP


RAS


Virgin
Binder

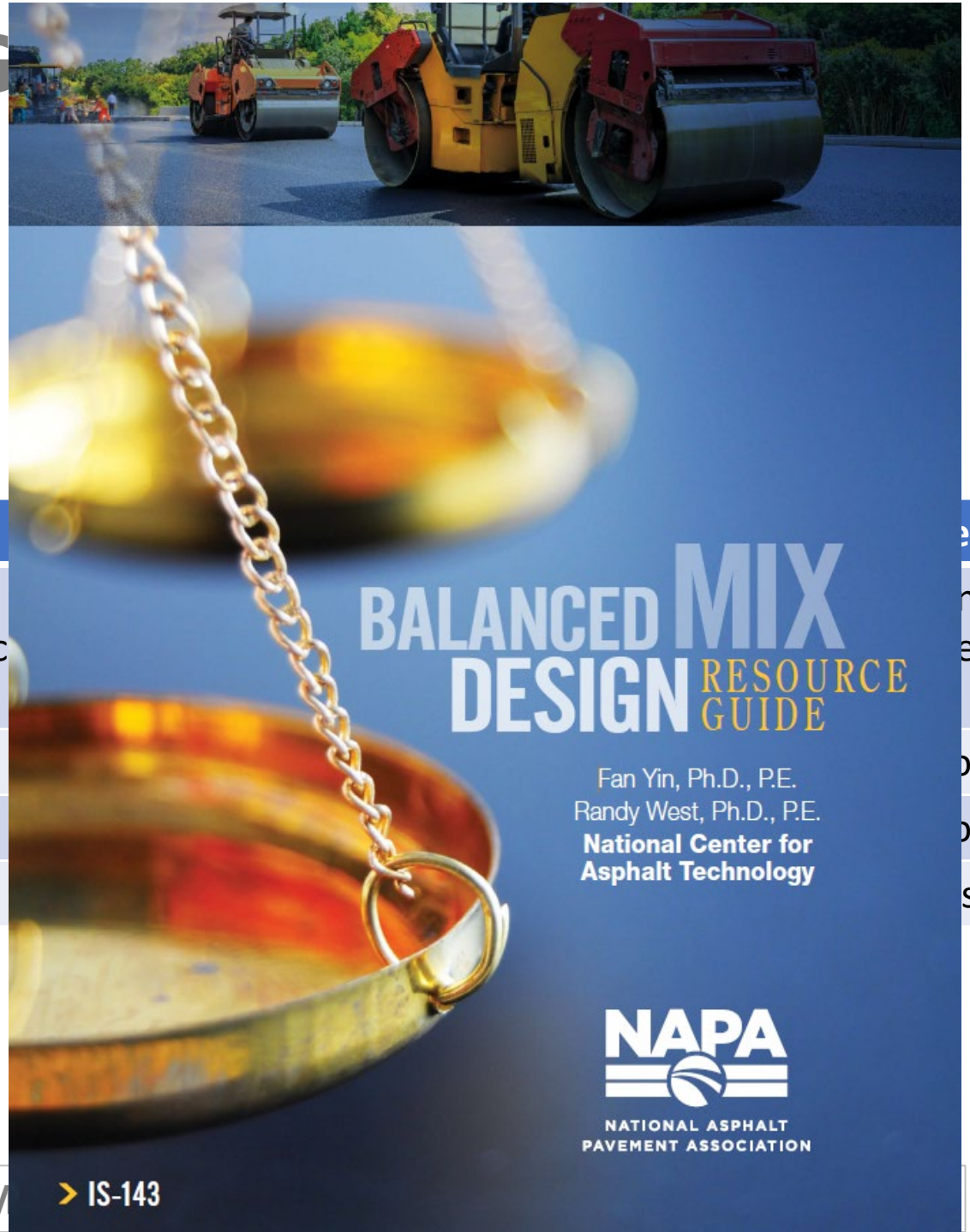

Recycling
Agents


Virgin
Aggregates


Rejuvenated
Mixture
Rejuvenated
Blend

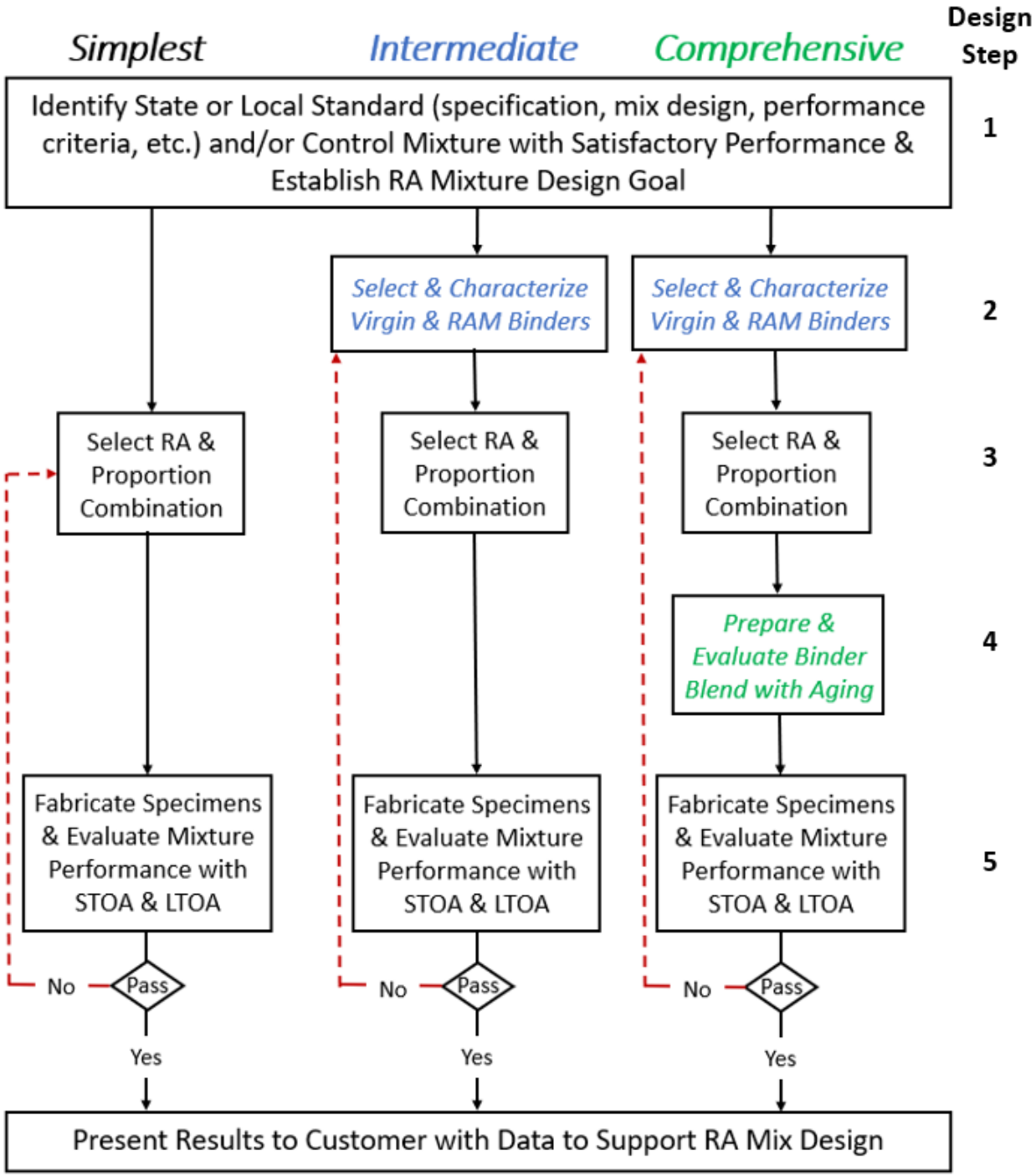
TIERED MIX DESIG APPROACHES

Approach		ed Testing		
	Field Performanc Risk	nder end	Mixture Rutting	Mixture Cracking
Simplest	Mod	o	Yes	Yes
Intermediate	Mod	o	Yes	Yes
Comprehensive	Low	s	Yes	Yes



APAM

MIX DESIGN

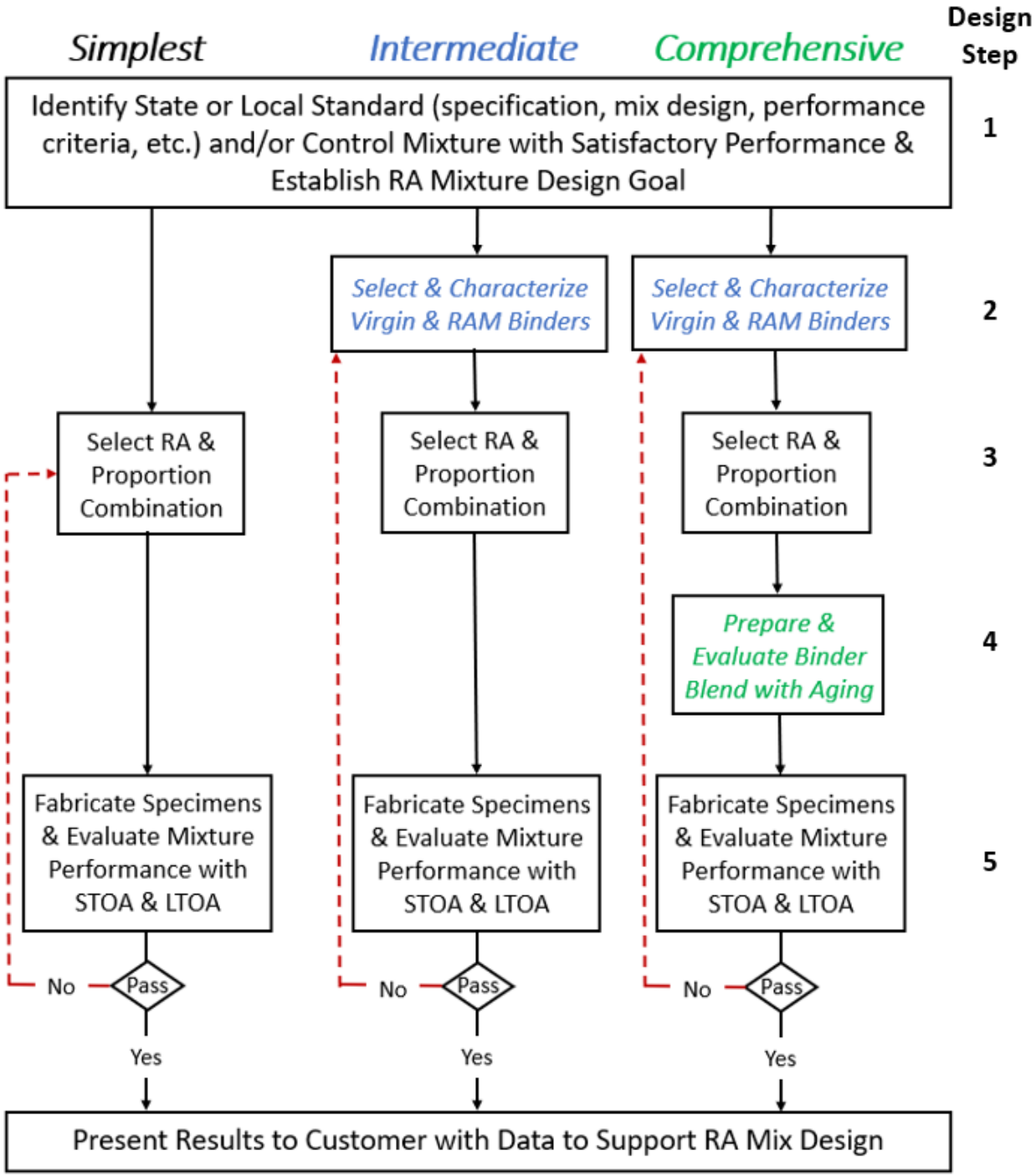


APA

MIX DESIGN

1. Identify State or Local Standards and/or Satisfactory Control Mixture & Establish RA Mixture Design Goal
   - Satisfy BMD rutting & cracking performance requirements
   - Increase RAM

MIX DESIGN



APA

MIX DESIGN

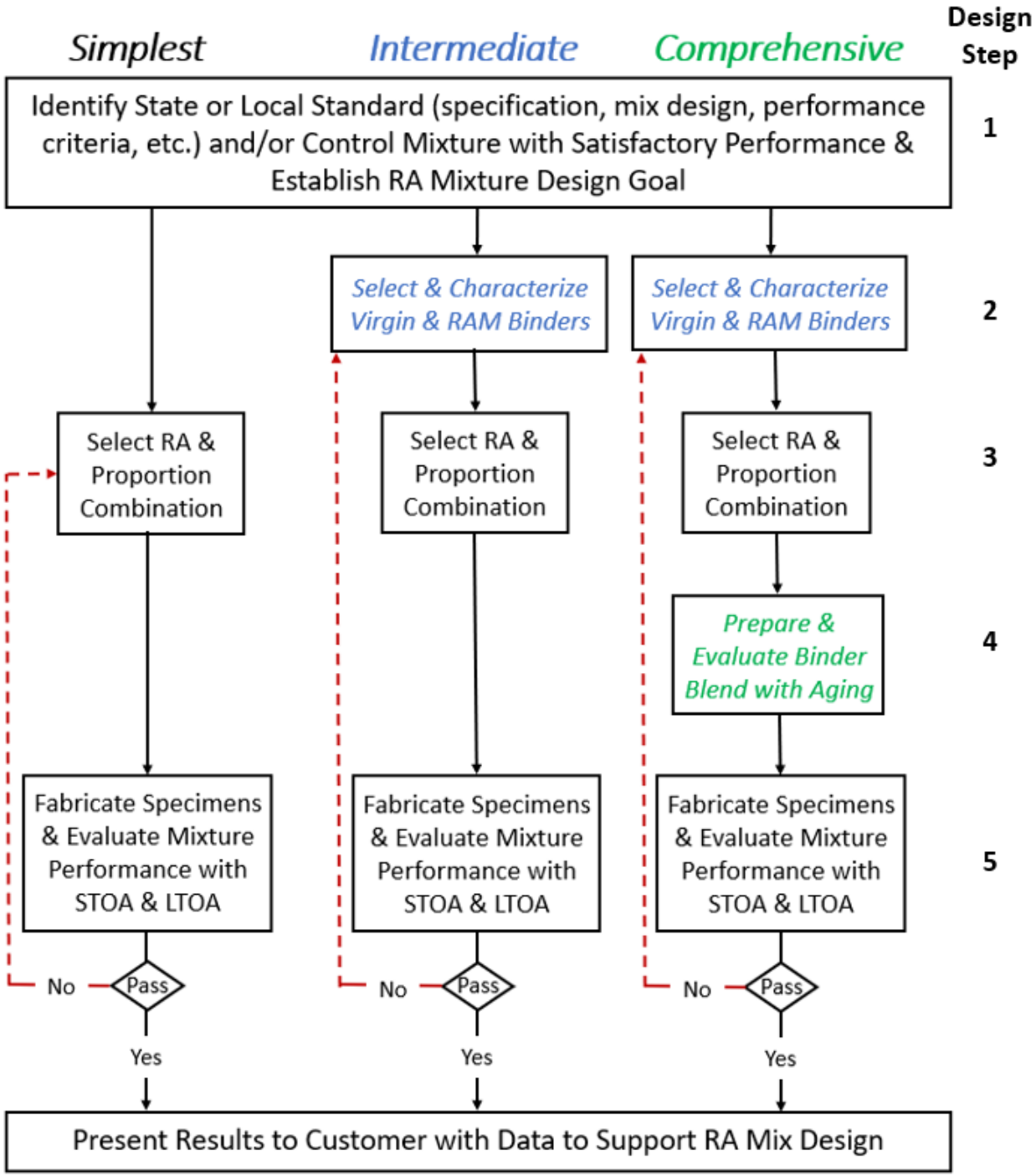
2. Select & Characterize Virgin and Recycled Binders

Parameter	Test Method	Temperature	Aging Condition(s)
PGH	AASHTO T 315	High	Unaged RTFO AASHTO T 240
ΔT_c	AASHTO T 313	Low	PAV (20hr) AASHTO R 28

MIX DESIGN

3. Select Recycling Agent & Proportion Materials Combination Including Appropriate Dose

MIX DESIGN

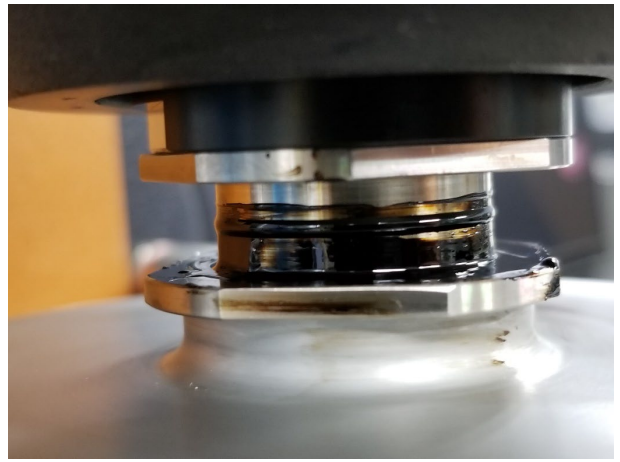


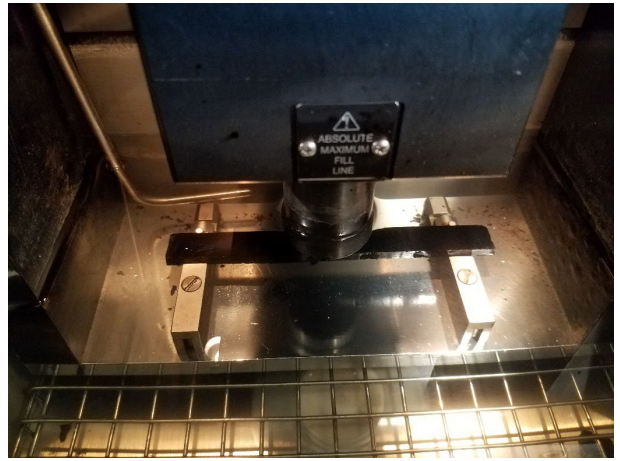
APA

MIX DESIGN

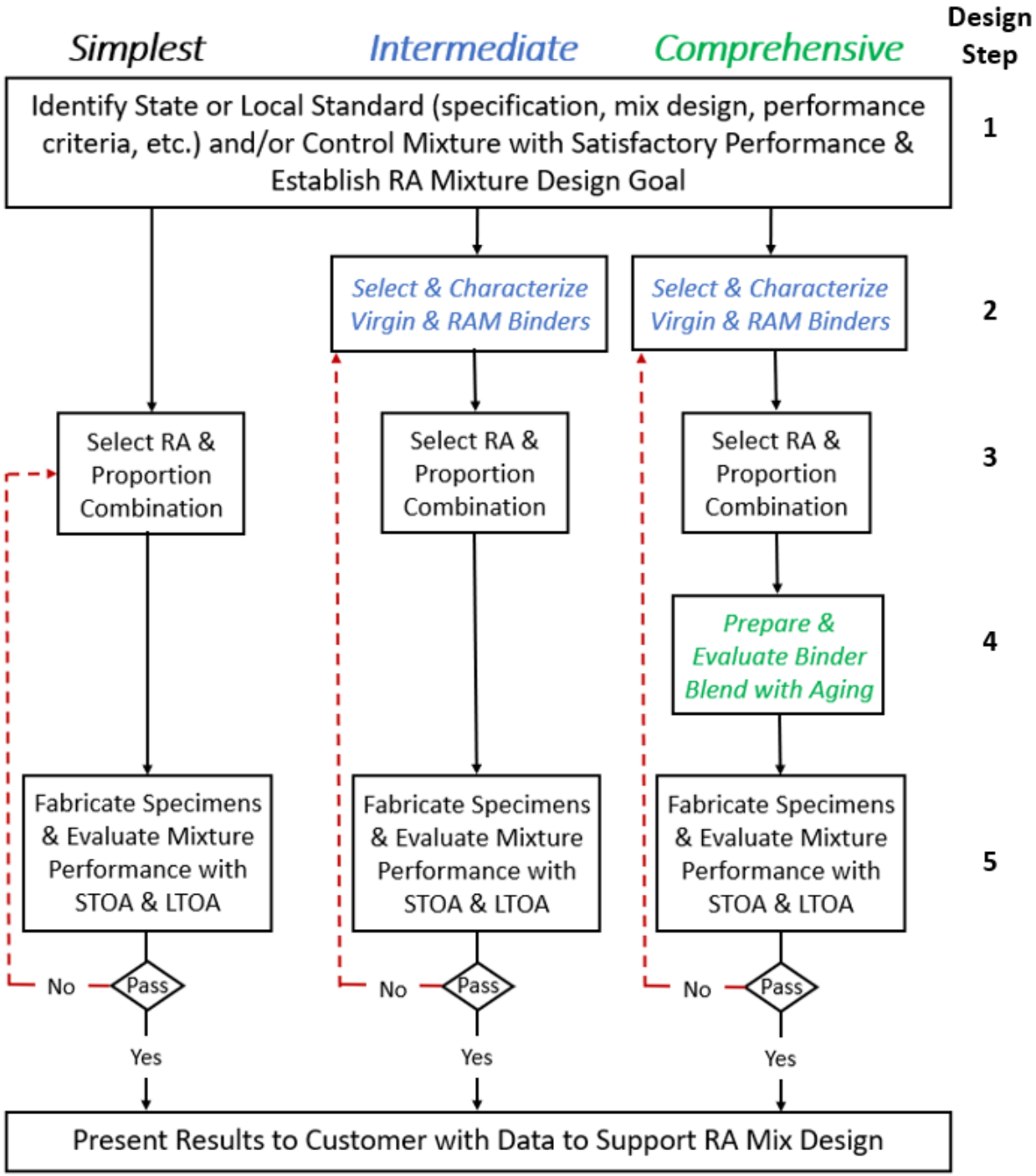
4. Prepare & Evaluate Binder Blend with Aging

Parameter	Test Method	Temperature	Aging Condition(s)
PGH	AASHTO T 315	High	Unaged RTFO AASHTO T 240
G-R	AASHTO T 315	Intermediate	RTFO AASHTO T 240 PAV (20-hour, 40-hour) AASHTO R 28
ΔT_c	AASHTO T 313	Low	PAV (20-hour) AASHTO R 28





MIX DESIGN

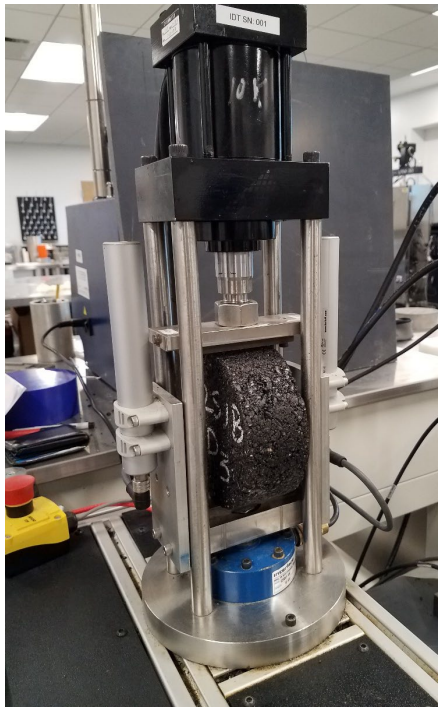


APA

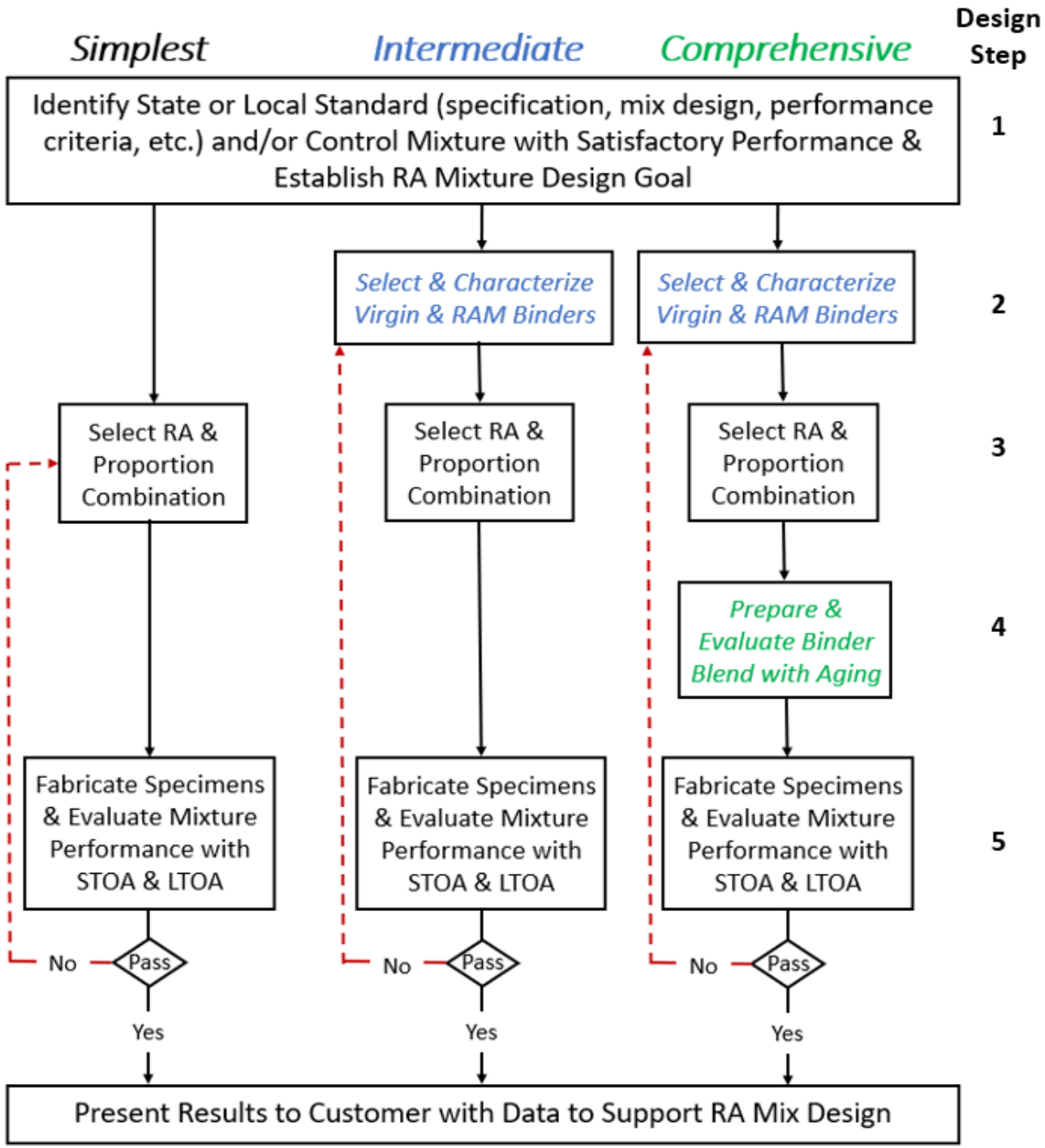
MIX DESIGN

5. Prepare Specimens & Evaluate Mixture Performance with Aging – *Example: What is Your Agency Using?*

Parameter	Test Method	Temperature	Aging Condition(s)
$N_{12.5}$	HWTT AASHTO T 324	High (50°C)	STOA AASHTO R 30
CT_{Index}	IDEAL-CT ASTM D8225	Intermediate (25°C)	LTOA AASHTO R 30
FI	I-FIT AASHTO TP 124	Intermediate (25°C)	LTOA AASHTO R 30
CRI_{Env}	UTSST ASTM WK60626	Low (10°C/hour from 20°C)	LTOA AASHTO R 30



MIX DESIGN


Simplest
Intermediate
Comprehensive
Design Step
Identify State or Local Standard (specification, mix design, performance criteria, etc.) and/or Control Mixture with Satisfactory Performance & Establish RA Mixture Design Goal
1
Select & Characterize Virgin & RAM Binders
Select & Characterize Virgin & RAM Binders
2
Select RA & Proportion Combination
Select RA & Proportion Combination
Select RA & Proportion Combination
3
Prepare & Evaluate Binder Blend with Aging
4
Fabricate Specimens & Evaluate Mixture Performance with STOA & LTOA
Fabricate Specimens & Evaluate Mixture Performance with STOA & LTOA
Fabricate Specimens & Evaluate Mixture Performance with STOA & LTOA
5
No
Pass
Yes
No
Pass
Yes
No
Pass
Yes
Present Results to Customer with Data to Support RA Mix Design

MIX DESIGN

5. Prepare Specimens & Evaluate Mixture Performance with Aging - *Example: What is Your Agency Using?*

Parameter	Test Method	Temperature	Aging Condition(s)
$N_{12.5}$	HWTT AASHTO T 324	High (50°C)	STOA AASHTO R 30
CT_{Index}	IDEAL-CT ASTM D8225	Intermediate (25°C)	LTOA AASHTO R 30
FI	I-FIT AASHTO TP 124	Intermediate (25°C)	LTOA AASHTO R 30
CRI_{Env}	UTSST ASTM WK60626	Low (10°C/hour from 20°C)	LTOA AASHTO R 30

MIX DESIGN

- **Volumetrics**
  - Consider effects of absorbed binder
    - VMA = AV + V_{be} = f(G_{sb})
    - DP = p_{200} / P_{be}
  - Reduce 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 lower ΔT_c
  - Adjust aggregate blend
  - Modify split between RAP_{BR} and RAS_{BR} or reduce RAS_{BR}
  - Reduce overall RBR

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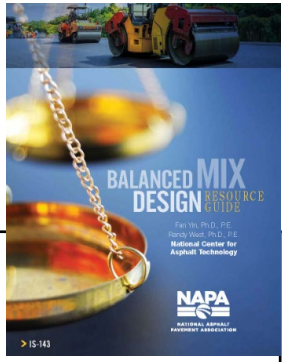
MIX DESIGN EXAMPLE – *SIMPLEST APPROACH*

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

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

MIX DESIGN EXAMPLE – INTERMEDIATE/COMPREHENSIVE APPROACHES

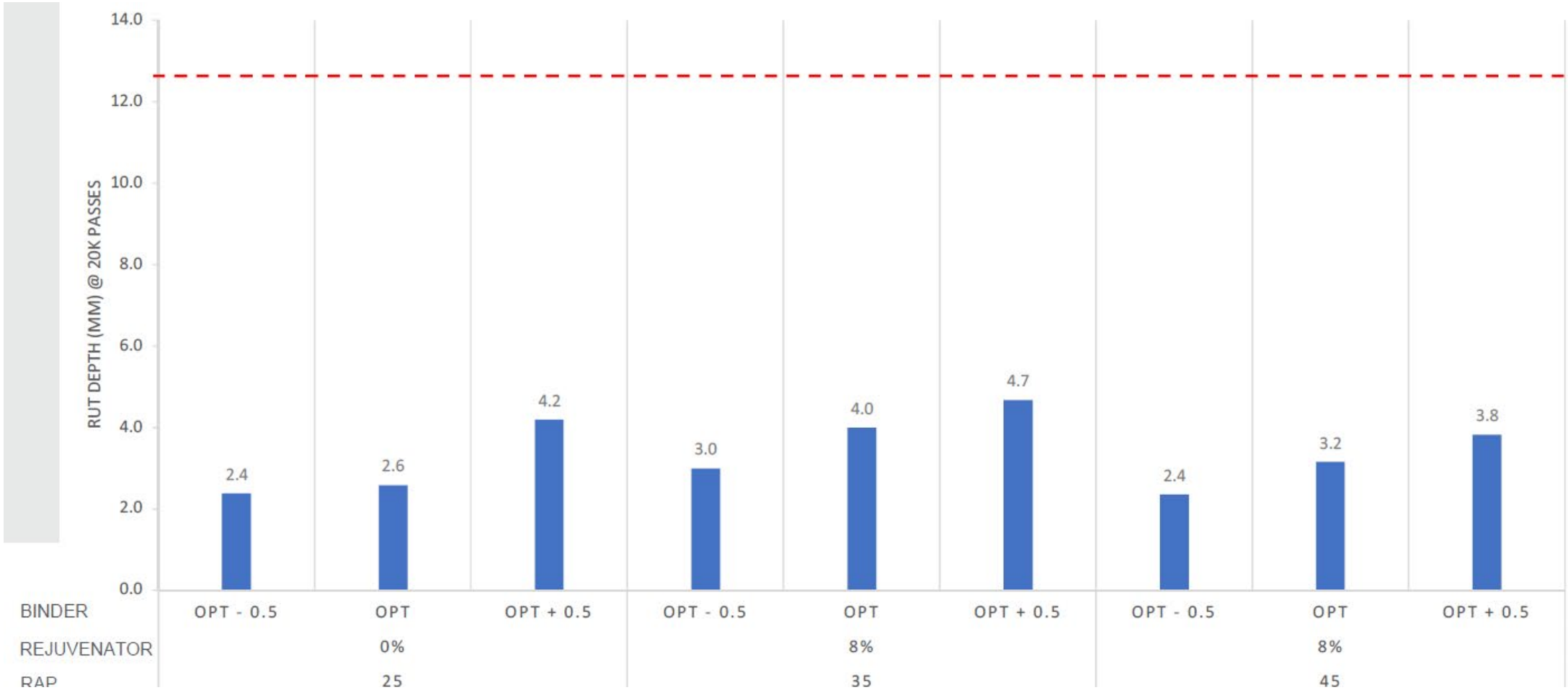
Mixture Properties	Virgin 0.0 RBR	DOT Control 0.22 RBR	Recycled 0.31 RBR	Recycled w/Softer Binder 0.31 RBR	Rejuvenated 0.31 RBR	Evaluation Criteria
Component Materials						
Virgin Binder PGH (°C)	59.4	59.4	59.4	52.3	59.4	Not specified
Virgin Binder ΔT_c (°C)	-3.4	-3.4	-3.4	+0.4	-3.4	$\geq$ -3.5°C
RAP 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

SIMPLE EXAMPLE 2

- Staker Parsons SLC
- Control: Typical 1/2“ Superpave Mix w/ 25% RAP
- RAP
  - 35%, 45%
- %AC
  - Optimum ± 0.5%
- Rejuvenator Dose
  - 0%, 8%
- Aging
  - R30 STOA, & CDD method
- Performance Tests
  - HWT, Ideal-CT, IFIT

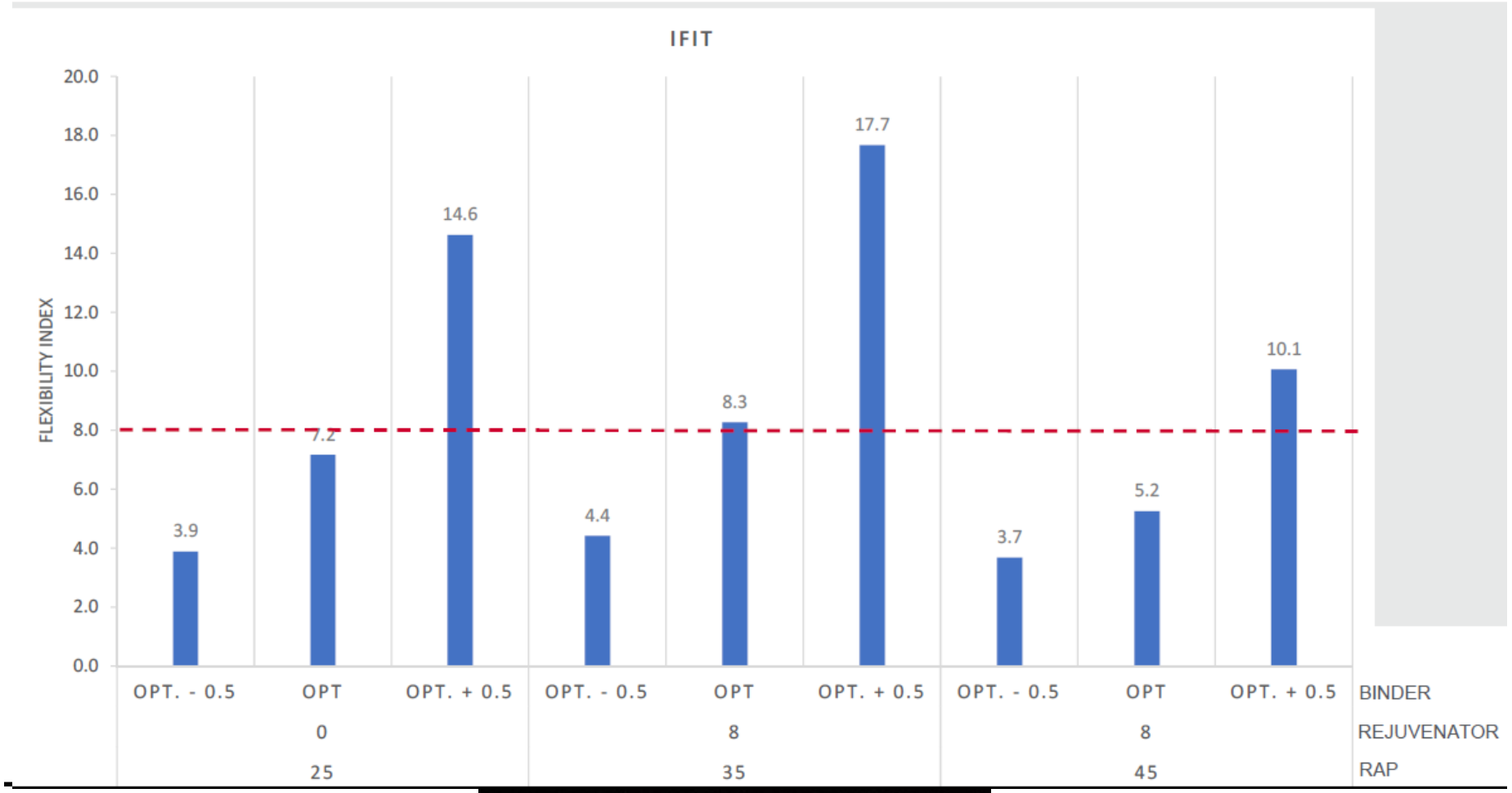
CRH - RMACE S. Buchanan
https://rmaces.org/docs/Balanced_Mix_Designs.pdf

HAMBURG WHEEL TRACK TESTS



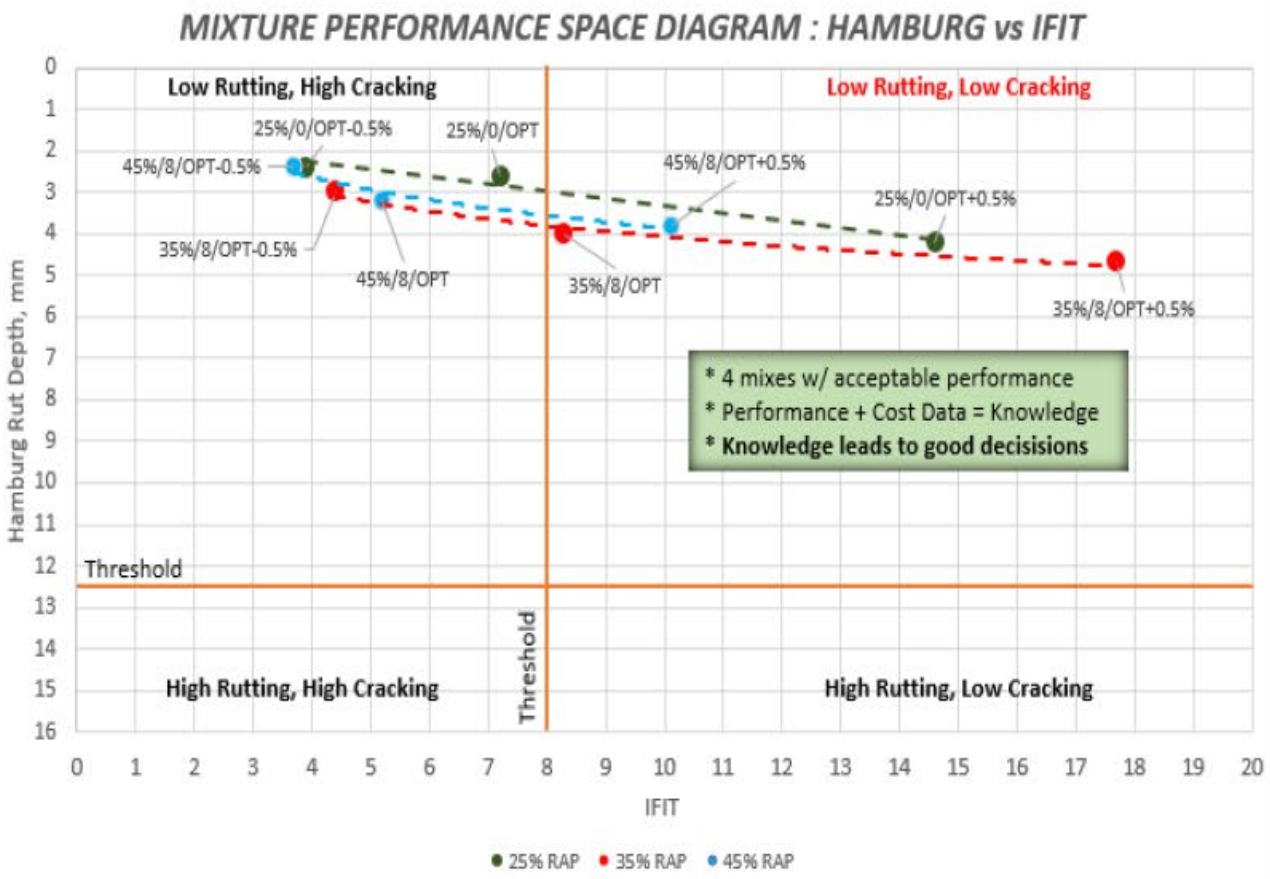
CRH - RMACE S. Buchanan
https://rmaces.org/docs/Balanced_Mix_Designs.pdf

IDEAL CT & IFIT



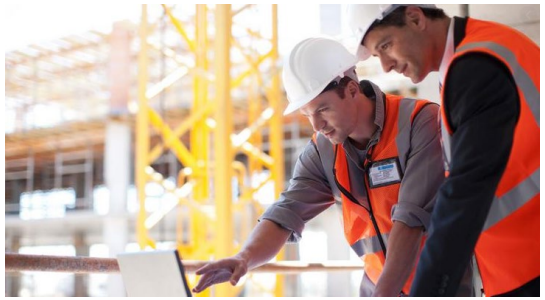
EXAMPLE

OPTIMIZATION EXAMPLE



PRODUCTION CONSIDERATIONS

- Mix Design
- Plant Production
- Paving Operations
- EH&S



PRODUCTION CONSIDERATIONS – MIX DESIGN

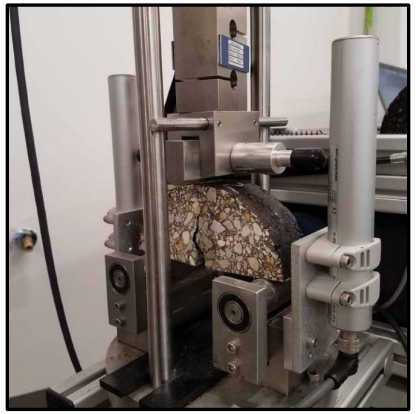
- Mix Design Goal: Use RAs to Optimize High RBR Mixes, Satisfy BMD Requirements, Improve Economics, & Minimize Environmental Impacts: *May Require Some Changes – Context Sensitive!*
  - Increased Number of Mix Designs?
  - More Rigorous Virgin Binder, RA, &/or Blended Binder Analysis?
  - Virgin Binder Mentality Change: *Commodity vs. Performance*?
  - Mix Aging Protocols/Time/Space?
  - Rutting and Cracking Performance Test Equipment?
  - Mix Designer Skillset and Training?
  - Laboratory Space?
  - Relationships with Service Providers?
  - Support of RA Suppliers?

PRODUCTION CONSIDERATIONS – MIX DESIGN

- Mix Design Equipment Costs
  - PG Binder Grading ≈ $150k
  - Hamburg Wheel Track Tester ≈ $50k
  - Cracking Tests ≈ $15 to $50^{+}k
  - Additional Preparation and Aging Equipment:
    - Ovens, Sawing, Coring, Notching Equipment/Jigs
- Other Considerations:
  - Laboratory Space for Above
  - Highly Skilled Technicians to Prepare and Perform Tests
  - Relationships with Suppliers vs. Investments?
  - When to Make Investments?
    - Understand Current Mixes under New Specs vs. Pilots vs. Full Implementation

STATES ARE RESEARCHING, PLANNING OR IMPLEMENTING BMD

- Long DOT History with Volumetrics in Mix Design & Acceptance
  - Relax or Eliminate with Performance Test Confidence Over Time
- For Improved Durability Through the Transition Consider
  - Getting Adequate Binder in Mixes
  - VMA based on virgin and RAM Gsb, not RAM Gse
  - Dust Proportion – Must Manage Fines
- If Challenged Meeting BMD Requirements Consider:
  - Increasing RA Dose or Different RA
  - Different Virgin Binder Supply or Softer PG
  - Adjusting Blend to Increase Binder Content
  - Modifying RAP, RAS, or RAP/RAS Split
  - Reducing RBR



PRODUCTION CONSIDERATIONS – PLANT OPERATIONS

- Additional Binder and/or Blending Tanks?
- RA can be Dosed at Plant or Terminal/Refinery
  - DOT/Agency Allow One or Both?
  - Flexibility to Adjust to RAM Level if at the Plant
    - DOT May Force Producer to COC Program
- If Blended at Plant *"On the Fly"* then Interlocked Controls, Calibration, …
  - Eliminates Need for Additional Asphalt Tanks
  - Small Doses: Right Sized Equipment – Pump, Meter, Blending Units Important
  - Temperature Compensation for Viscosity in Cool Climates
    - Pre-Heats Needed?
  - Adequate Blending Prior to Introduction into Drum Necessary
  - AASHTO M156 if Agencies Don't Have 109 Procedure

PRODUCTION CONSIDERATIONS – PLANT OPERATIONS

- Consistent RAP and RAS Production, Handling and Management
  - NAPA QIP-129 Best Practice on RAM Production for Consistency
  - In-Bound Sorting, Crushing, Fractionation
  - Stockpiling BPs
  - Moisture Management, Paving Under, Covering
    - Depends on Geographical Location
    - BPs Vary with Precipitation Levels
  - Feeding Best Practices
  - RAM vs. Virgin Aggregate Bins

PRODUCTION CONSIDERATIONS – PLANT OPERATIONS

- Consistent RAP and RAS Production, Handling and Management (Cont.)
  - NAPA QIP-129 Best Practice on RAM Production for Consistency
  - Appropriate Feed Bins with Scalping Screens, Air Cannons, Vibrators, Scalping to Re-Circ Crusher & Screen
  - Multiple Bins for High RAM
  - Weigh Bridges Guarded from Elements
  - RAS Feed Low Very Percentages/Mass
    - Specialty/Modified Feed Bins
    - Weigh Bridge Sensitivity

PRODUCTION CONSIDERATIONS – PLANT OPERATIONS

- Consistent RAP and RAS Production, Handling and Management
  - NAPA QIP-129 Best Practice on RAM Production for Consistency
- Flighting & tuning Modifications?
- High RBR Mixes:
  - RAM % = f(plant type)
  - Counterflow Drums
  - Drum in Drum
  - Longer Drums
  - Fines Management
  - External Mixing Chambers

PRODUCTION CONSIDERATIONS – PLANT OPERATIONS

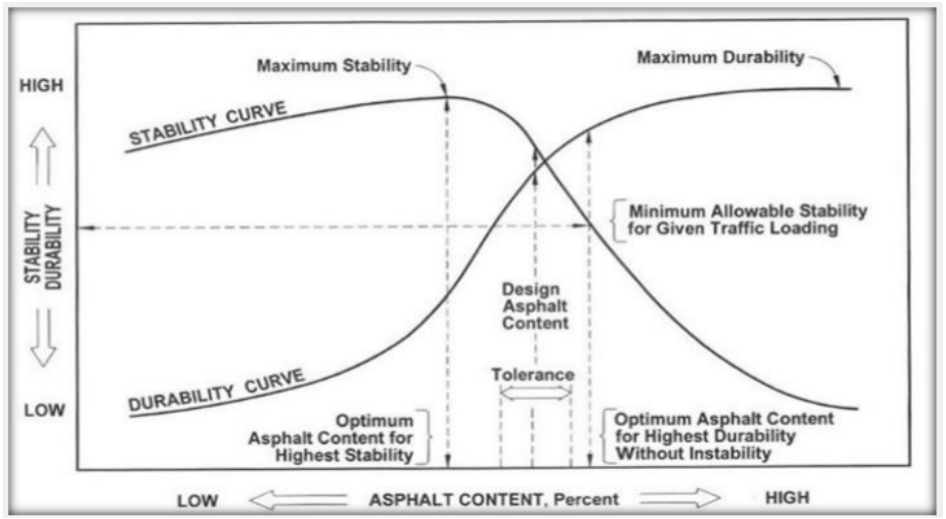
- See NAPA SR-213
- Fines Management
  - Washing Aggregates
  - Especially Crusher Fines
- Primary Collector Role
- Baghouse
  - Collected Fines
  - Metered Return
  - Ability to Waste
  - DP Specifications
  - Environmental Management

PRODUCTION CONSIDERATIONS – PAVING OPERATIONS

- Fewer Impacts
- Workability and Density Most Important
  - Can Be Improved with RA?
- Right Resources for the Job
- Cool Weather Paving
- WMA for Environment, Compaction, Moisture Sensitivity?
- Workability, Hand Work, Segregation & Joints – Same Game

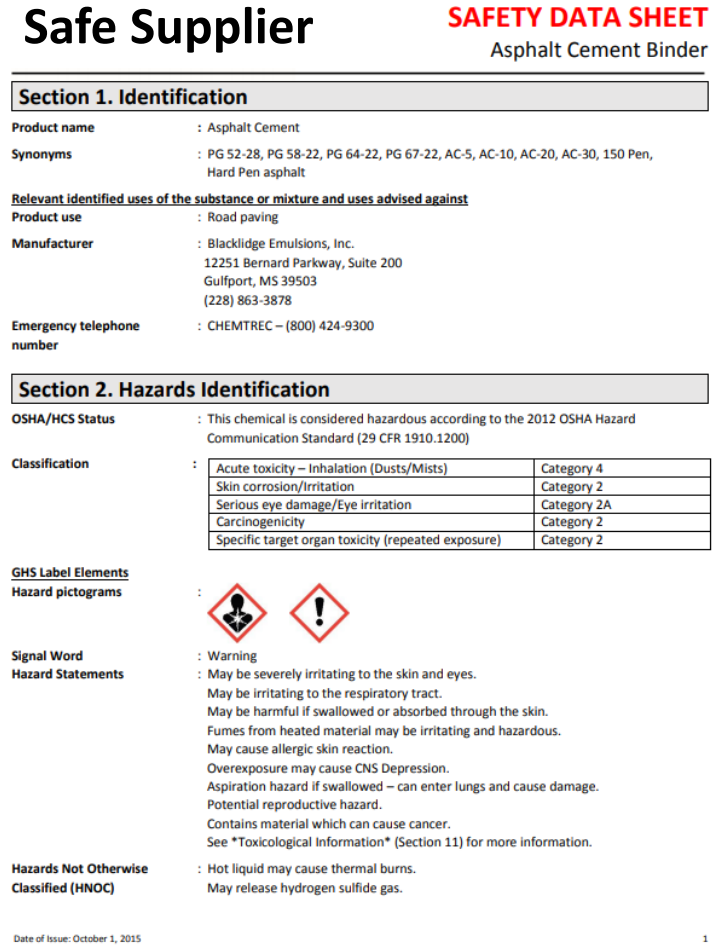
QUALITY CONTROL

- BMD with Production Performance Testing
  - Additional QC
    - Binder - *Yes*
    - RA - *Yes*
    - Aggregates - Same
    - RAM – Yes if Significant Dose Increases
    - Mat and Joint Density Control – Yes
    - Meeting Volumetric and Performance Test – Yes: VMA control & Cracking test control
  - Additional Resources Initially?
- Production, Con Ops and QC Relationship & Communications Important



PRODUCTION CONSIDERATIONS - EH&S

- As with Any Raw Material Review RA SDS
  - Equipment – pH
- Bio-Based May Pose Lower Risks than Conventional RAs
- EH&S Experts Interviewed Unaware of Any Risks
- Some Comments About Aromas Worth Noting
- Human Detection Level Below Hazardous Level
  - Be a Good Industry Representation and Neighbor
  - Understand and Pro-Actively Communicate



Safe Supplier

SAFETY DATA SHEET
Asphalt Cement Binder

Section 1. Identification

Product name : Asphalt Cement

Synonyms : PG 52-28, PG 58-22, PG 64-22, PG 67-22, AC-5, AC-10, AC-20, AC-30, 150 Pen, Hard Pen asphalt

Relevant identified uses of the substance or mixture and uses advised against

Product use : Road paving

Manufacturer : Blacklidge Emulsions, Inc.
12251 Bernard Parkway, Suite 200
Gulfport, MS 39503
(228) 863-3878

Emergency telephone number : CHEMTREC – (800) 424-9300

Section 2. Hazards Identification

OSHA/HCS Status : This chemical is considered hazardous according to the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Classification :

Acute toxicity – Inhalation (Dusts/Mists)	Category 4
Skin corrosion/Irritation	Category 2
Serious eye damage/Eye irritation	Category 2A
Carcinogenicity	Category 2
Specific target organ toxicity (repeated exposure)	Category 2

GHS Label Elements

Hazard pictograms :

Signal Word : Warning

Hazard Statements : May be severely irritating to the skin and eyes.
May be irritating to the respiratory tract.
May be harmful if swallowed or absorbed through the skin.
Fumes from heated material may be irritating and hazardous.
May cause allergic skin reaction.
Overexposure may cause CNS Depression.
Aspiration hazard if swallowed – can enter lungs and cause damage.
Potential reproductive hazard.
Contains material which can cause cancer.
See *Toxicological Information* (Section 11) for more information.

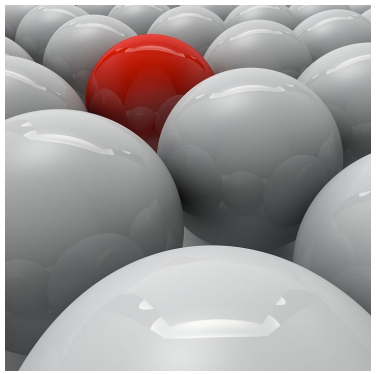
Hazards Not Otherwise Classified (HNOC) : Hot liquid may cause thermal burns.
May release hydrogen sulfide gas.

Date of Issue: October 1, 2015

1

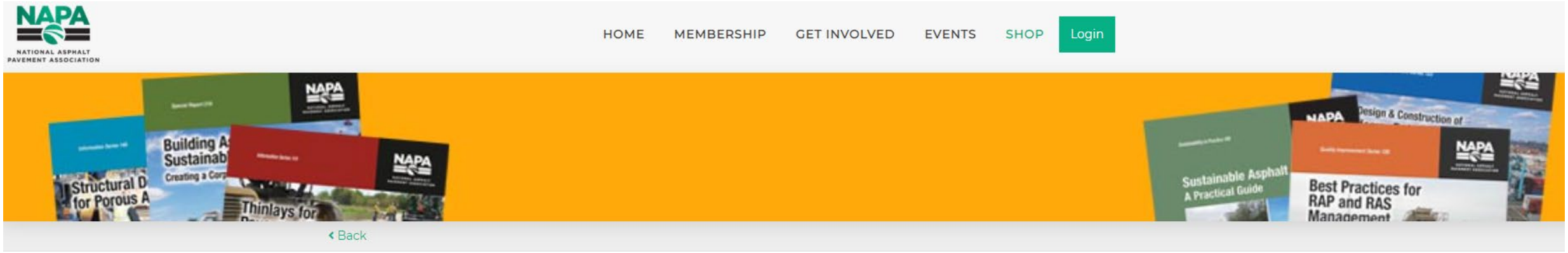
SUMMARY

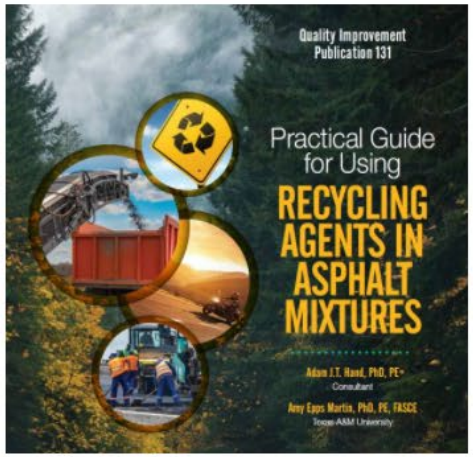
- RAs can be Used to Produce High RAM Mixes with Good Performance
- Key Considerations Include: Material Selection, Mix Design, Plant Production, Paving Operations, Related Investments, and EH&S
- Producers Need to Balance Rigor/Risk and Cost/Time & Equipment Needs
- Every Contractor's Situation is Unique
- *Every Materials Combination is Unique*
  - *Virgin Binder Quality & Consistency is Critical*
  - *Not all Recycling Agents are Equal*
- ***Long-term Aged Mixture Cracking Testing is Important***
- Don't Lose Sight of Sustainable Benefits for Our Industry
  - They are Significant and Important
  - They Create Value for Businesses, Individuals and the Communities We Live In!
- Promote Responsible High RAM Use and Support Use with Data
- Don't Forget Quantifying Doses and EH&S Considerations
- Demonstrate BPs for Industry and Recycling!



ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN

HOW TO GET THE PRACTICAL GUIDE





Practical Guide for Using Recycling Agents in Asphalt Mixtures PDF

NEW! NAPA Store

Adam J.T. Hand, Ph.D., P.E.; Amy Epps Martin, PhD, PE, FASCE

Government/Academia: $0.00
Member: $0.00
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Published: 9/15/2020
Pages: 32
This guide provides a tiered set of step-by-step approaches to facilitate the use of recycling agents in asphalt mixtures to produce pavements with good performance and promote sustainability.

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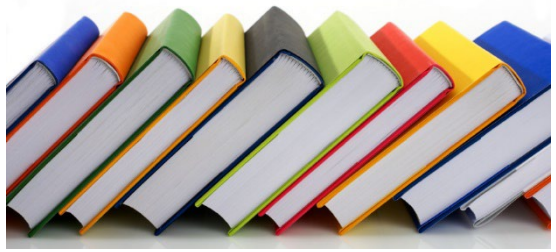
OTHER NAPA RESOURCES



- NAPA IS-143 *Balanced Mix Design Resource Guide*
- NAPA IS-138 *Annual Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage: 2018, 9th Annual Survey* (2019)
- NAPA QIP-129E *Best Practices for RAP and RAS Management* (2015)
- NAPA IS-136E, 2nd Ed, *Guidelines for the Use of Reclaimed Asphalt Shingles in Asphalt Pavements* (2019)
- NAPA SR-213E *Use of RAP & RAS in High Binder Replacement Asphalt Mixtures: A Synthesis* (2016)
- NAPA QIP-126 *Energy Conservation in Hot-Mix Asphalt Production* (2007)
- NAPA IS-123E *Recycling Hot-Mix Asphalt Pavements* (2007)
- NAPA SIP-100 *Sustainable Asphalt Pavements: A Practical Guide* (2019)

THANK YOU!

Q&A?

Adam Hand

adamhand@unr.edu

(775) 742-6540 (cell)

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