IMPROVING PERFORMANCE OF HIGH-RAP HMA WITH BIO-OILS

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OUTLINE




- Recycling Benefits & Policies
- RAP Usage & Sustainability
- Best Practices
- Defining Recycling Agents (RA)
- Use of RA to Increase RAP Usage: Case Studies
- Ongoing Research
- Summary & Conclusions

FHWA RECYCLING POLICY

The policy states:

- Recycling and reuse **can offer engineering, economic, and environmental benefits**.
- Recycled materials should **get first consideration** in materials selection.

Restrictions that prohibit the use of recycled materials without technical basis **should be removed from specifications**.

- Any material used in highway or bridge construction, be it virgin or recycled, shall not adversely affect the performance, safety or the environment of the highway system.

Source : Wright, F.G., Jr.;
https://www.fhwa.dot.gov/legsregs/directives/policy/recmatmemo.htm

RAP USAGE (US)

Average RAP used in mix : **15.6 % (2009)** to **20.1 (2017),**

Estimated RAP stockpiled at end of 2017 season **: 102.1 MM Tons**

In the US, a reported **23 percent of RAP is fractionated**.

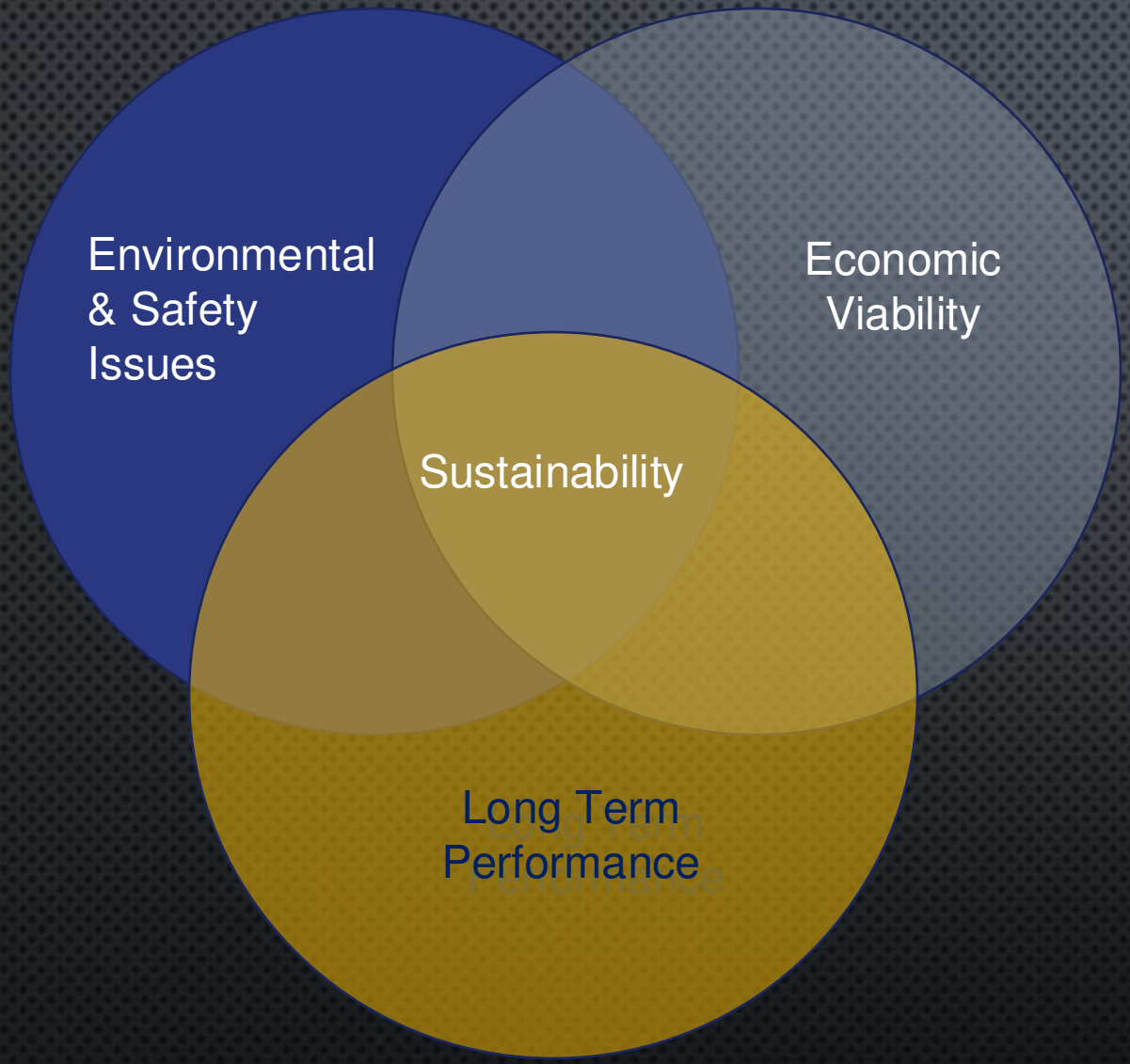
Producers from **31 states reported using softer binders** and **15 states reported using recycling agents** in RAP mixtures.

When asked about limiting factors in the use of RAP, the **top-three responses were**

- **specification limits** (38.5 percent)**,**
- **RAP availability** (18.5 percent), and
- **asphalt plant capabilities** (15.4 percent)

Source : NAPA

Sustainability Goals



- Are there any safety issues during paving?
- What is most effective RAP Content to minimize CO_2 emissions?

- What are the cost savings associated with RAP usage?
- What is most cost-effective RAP content?

- How long will the recycled asphalt last for?
- Will roadway age faster when using RAP?
- At what level of RAP does a recycled roadway perform the best?

The benefits of low-carbon asphalt are clearly understood, and the potential savings by simply using existing practices are in the order of 24 percent (NAPA – 2019 Baseline)

IMPROVING ROAD SUSTAINABILITY

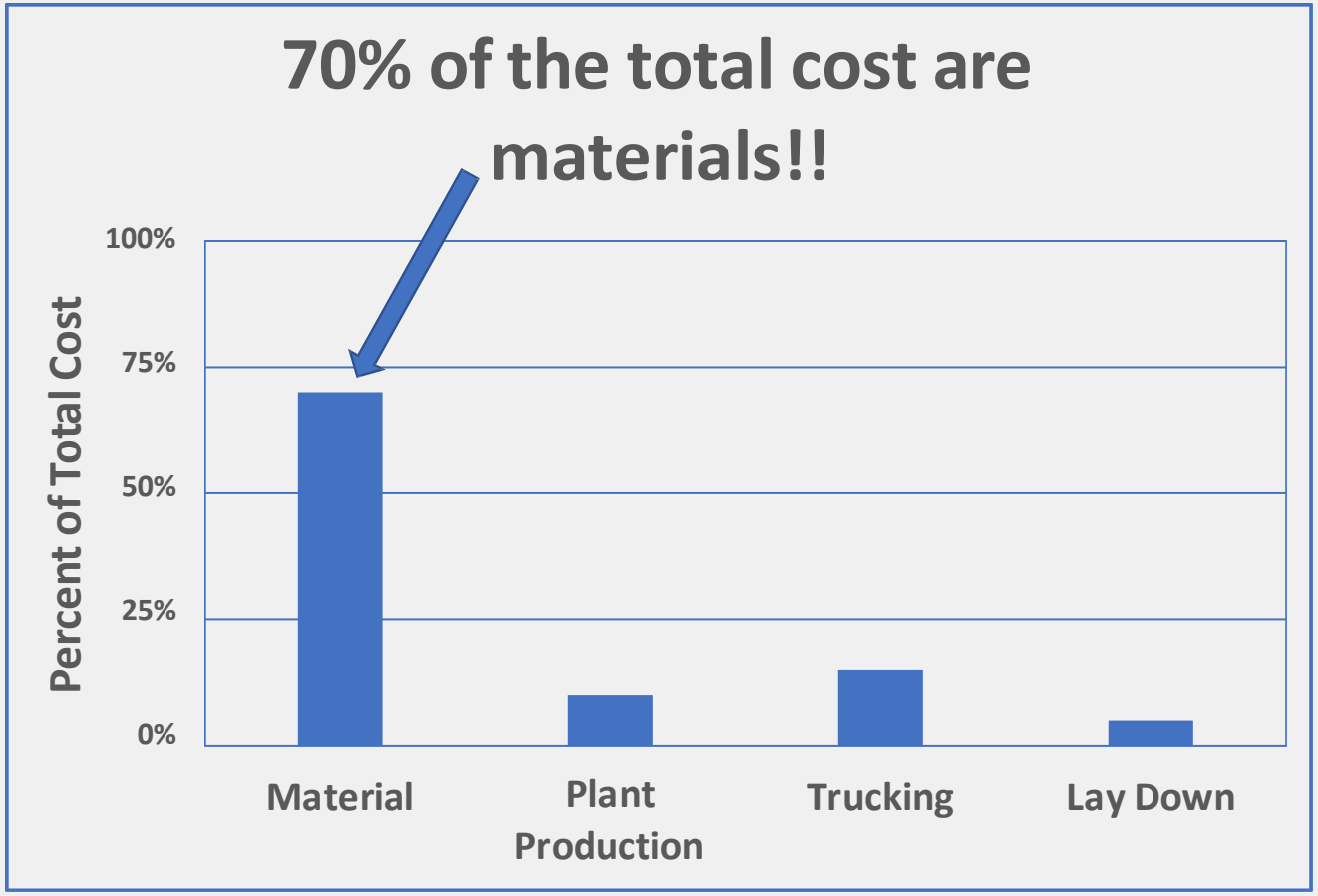
- **Use of Recycled Materials**
  - RAP & RAS
  - Recycled Tires
  - Recycled Concrete
- **Reduce Energy and Emissions**
  (Production/Construction)
  - Warm Mix Asphalt
  - Asphalt Emulsions and Cold Mix
- **Improved Service Life**
  - Modified Bitumen and Asphalt Mixtures
  - Mechanistic Design
  - More advanced PG grading and Balanced Mix Design

THE CASE FOR GREATER RAP USE

Economic benefits

- Using RAP typically **lowers the unit cost of HMA in** terms of aggregates and asphalt binder reuse.
- The most economical use of RAP is in asphalt mixtures.

Asphalt Mixes : Current State



Source : FHWA-HRT-11-021

Time Period of Study	Findings	Source
Pre-2000	Using 20-50% RAP may provide cost savings of 20-50% when materials & construction costs were considered….potential savings of 1% of mixture cost for every 1% of RAP used	Kandhall & Mallick (1997)
2004 & 2006	Savings of about 7-8% with 10% RAP, 15% with 20% RAP, and 20-22% with 30% RAP	Vukosavlievic (2006)
2006	Using 20% RAP had a potential to save about $42 MM per year in asphalt cement costs	Ontario Hot Mix Producers Association (2007)
2010	Estimated FL DOT saved $38 MM in materials costs in 2010 with Recycling Program. About 78% of all FL mixes contained RAP (average about 20%)	West & Willis (2014)
2011	Estimated savings of $3-5 per ton of mix using 5-7% of RAS (Missouri)	
2012	About 5% RAS reduces mix costs by 13% (TX). Use of RAP & RAS may reduce costs by up to 20%	
2012	Material cost savings calculated between 15-20% at 30% RAP and between 31-35 % with 50% RAP	Willis et. al. (2012)

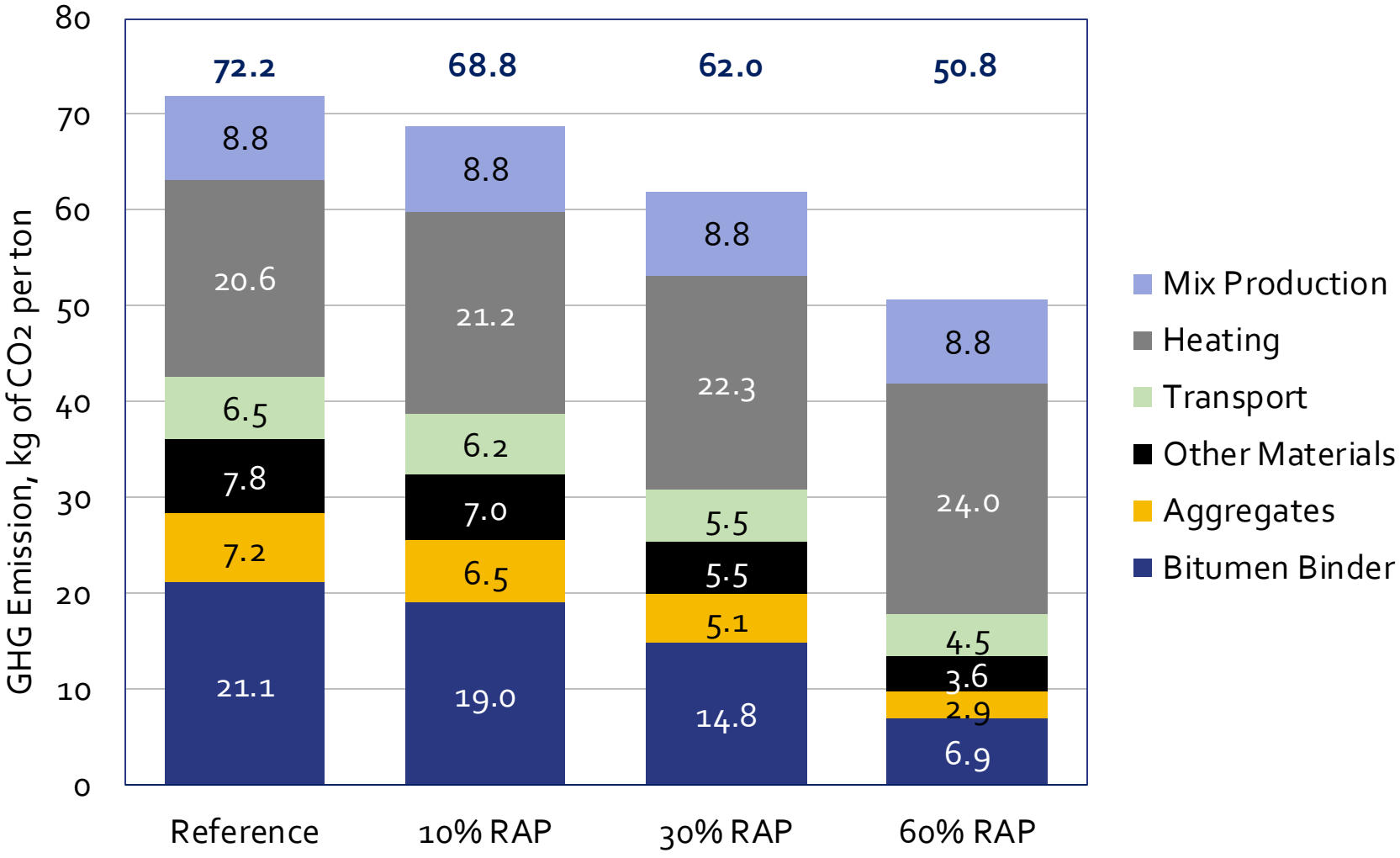
THE CASE FOR GREATER RAP USE

Environmental benefits

- **Conserve** non-renewable virgin binder and aggregate resources,
- **Reduce** energy & transportation costs,
- **Reduce** amount of construction debris going into landfills.

RAP use creates a cycle of asphalt reuse that optimizes use of natural resources and helps sustain the asphalt pavement industry.

Impact of Recycling Agents with Higher RAP Contents on GHG Emissions



Source : N Michel at AfPA Tech Talk, Australia, Nov 23, 2021

DEVELOPMENT OF NATIONAL GUIDELINES

- **NCHRP Synthesis 495 (2016):**
  - Use of Reclaimed Asphalt Pavement and Recycled Asphalt Shingles in Asphalt Mixtures
- **NAPA Quality and Information Series 2008-2017**
- **NCHRP Digest Number 253:**
  - Recommended Use of Reclaimed Asphalt Pavement in the Superpave Mix Design Method Guidelines"
- **NCHRP Report 452:**
  - Recommended Use of RAP in the Superpave Mix Design Method: Technician's Manual"
- **NCHRP Report 752:**
  - Improved Mix Design, Evaluation, and Materials Management Practices for Hot Mix Asphalt with High Reclaimed Asphalt Pavement Content"
- **National Standards**
  - AASHTO M323, New Appendix: Superpave Volumetric Design
  - AASHTO PP53: Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in New Hot Mix Asphalt (HMA)"

Sources of RAP

Pavement Milling

Asphalt Pavement Removal

Plant Waste Material

Source : RMAUPG, J. D'Angelo

Processing RAP

Screening

Crushing

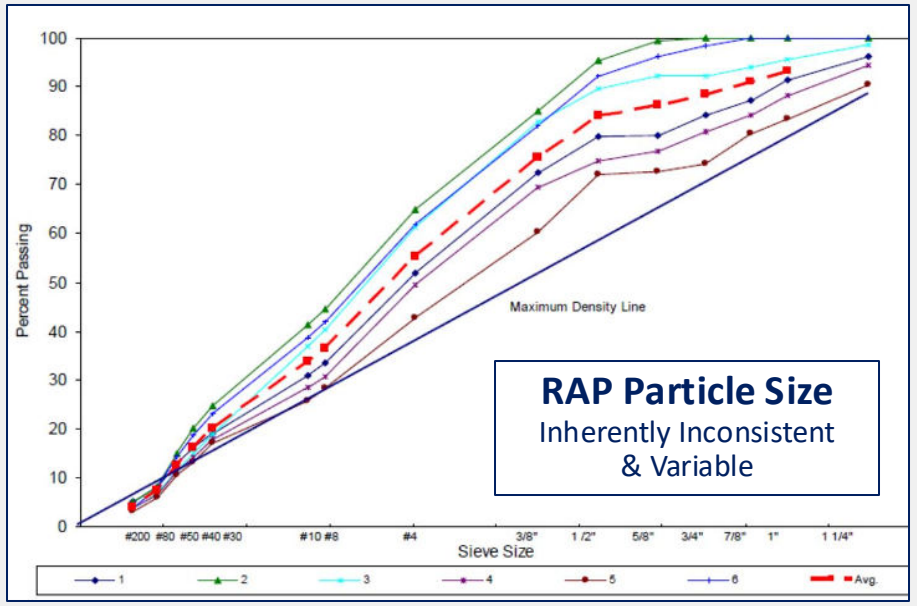
Fractionating

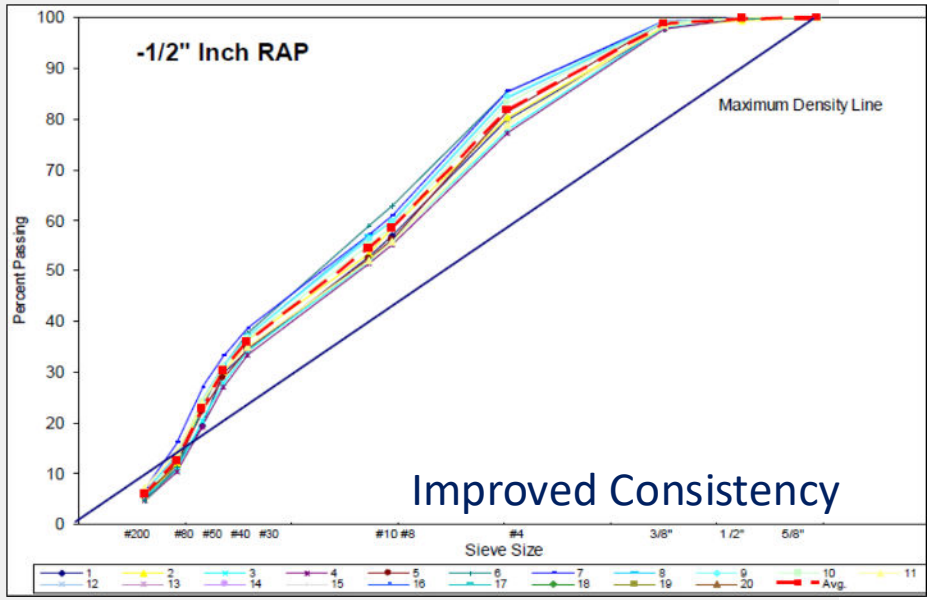
Source : RMAUPG, J. D'Angelo

Fractionating RAP by Size

Source : RMAUPG, J. D'Angelo

Improve RAP Consistency & Quality



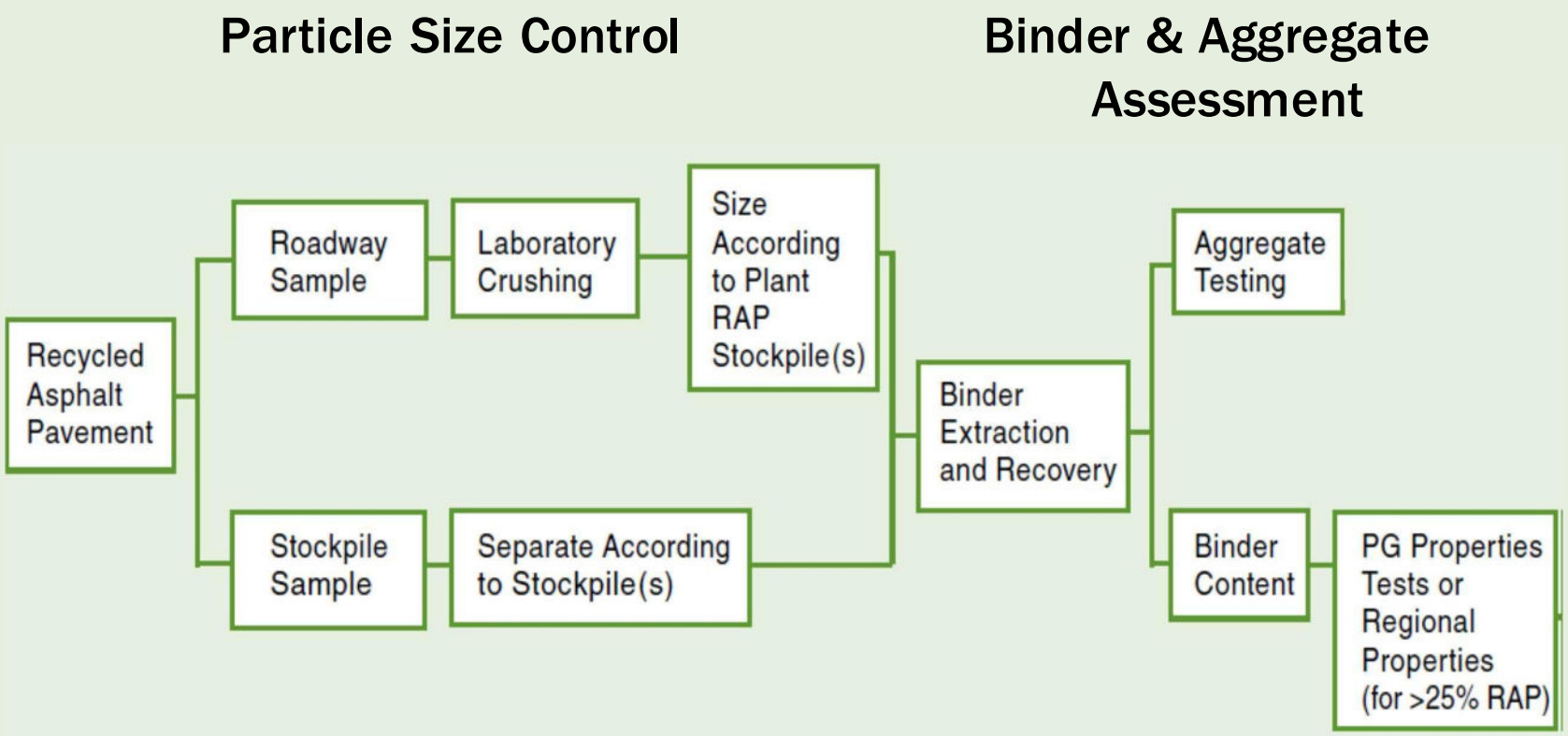


- Consistent Aggregate Gradation
  - Minimize Dust in RAP
  - Ensure Consistent Surface Area
- RAP Pre-Heating Needed
- Moisture in RAP Should be Monitored
- Analyze the RAP

Achieving Higher Levels of Process & Quality Control

Source : University of Wisconsin – Madison, RMAUPG, J. D'Angelo

Defining RAP Quality



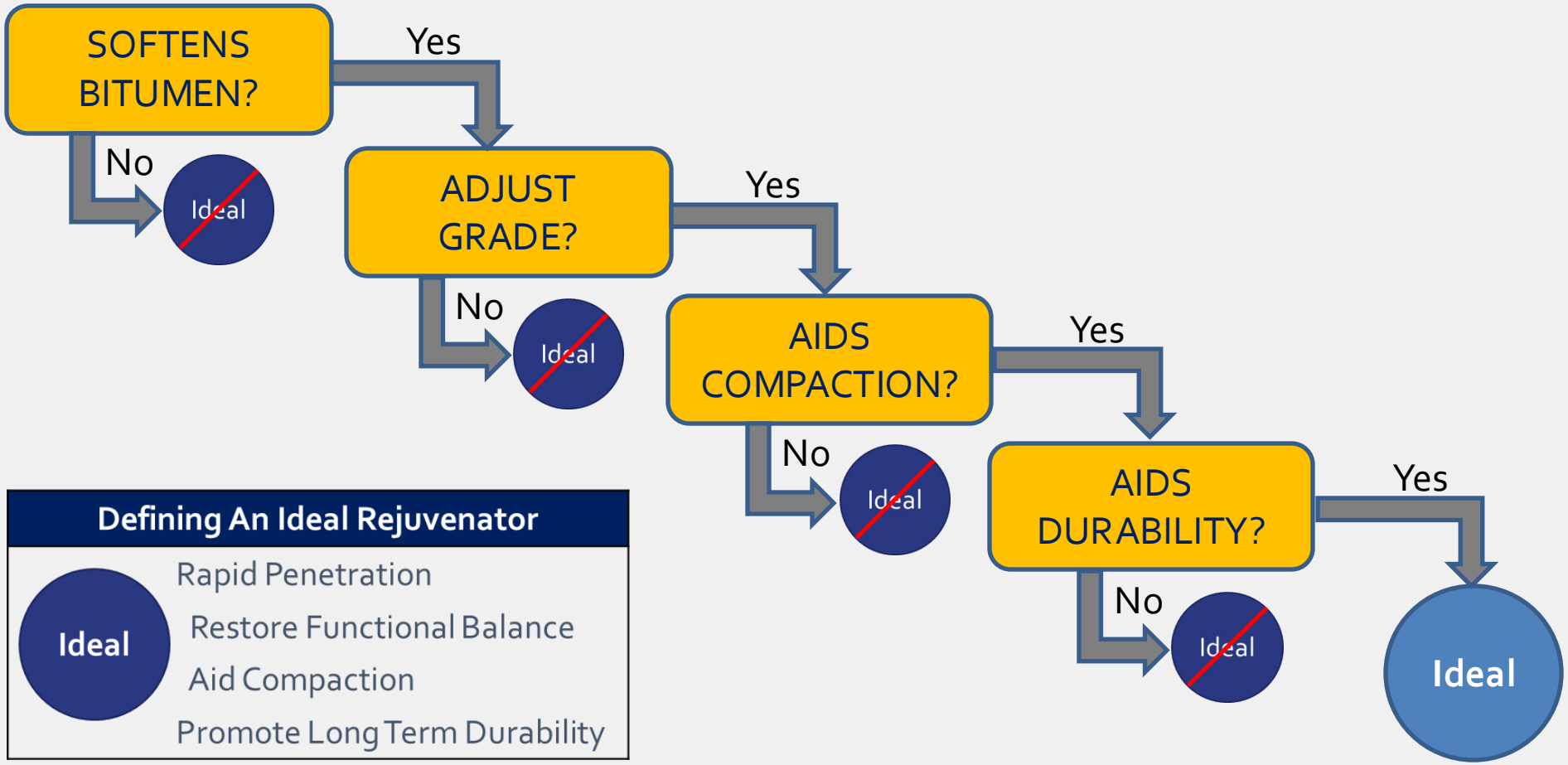
Source : NAPA Quality Improvement Series, 124

Rejuvenating or Recycling Agent Types

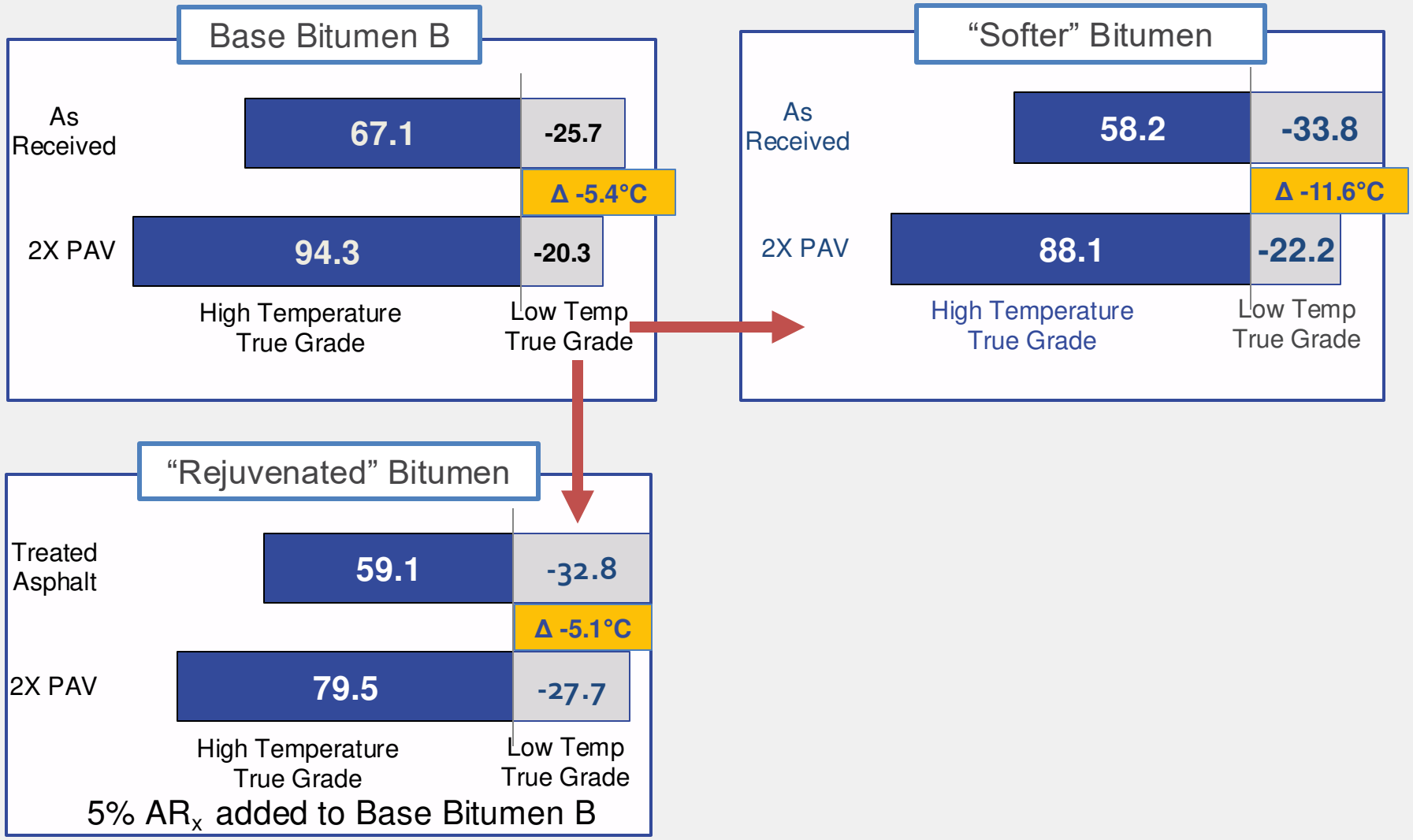
- Softer Grade Bitumen
- Petroleum
  - Paraffinic Oil
  - Aromatic Oil
  - Naphthenic Oil
  - Proprietary Oils
- Bio-based Oil
  - Proprietary Blends
- Refined Used Oil:
  - Re-refined Used Motor Oil: REOB

Key Factors Influencing Optimal Recycling Agent (RA) Dosage

Key Areas	Key Factors Influencing Dosage
Reclaimed Asphalt Pavement (RAP) Properties	Amount of binder from RAP Age of RAP Binder
New Binder Requirements	New Bitumen Source & Specification Total Amount of Binder Required in the Mix Amount of New Binder
RAP Content	High RAP Levels Require Recycling Agent
Other Factors	Good Plant Operations Mix Performance Specifications


SOFTENS BITUMEN?
Yes
No
Ideal
ADJUST GRADE?
Yes
No
Ideal
AIDS COMPACTION?
Yes
No
Ideal
AIDS DURABILITY?
Yes
No
Ideal
Ideal
Defining An Ideal Rejuvenator
Ideal
Rapid Penetration
Restore Functional Balance
Aid Compaction
Promote Long Term Durability

Rejuvenated Bitumen Compared to Softer Grade Bitumen



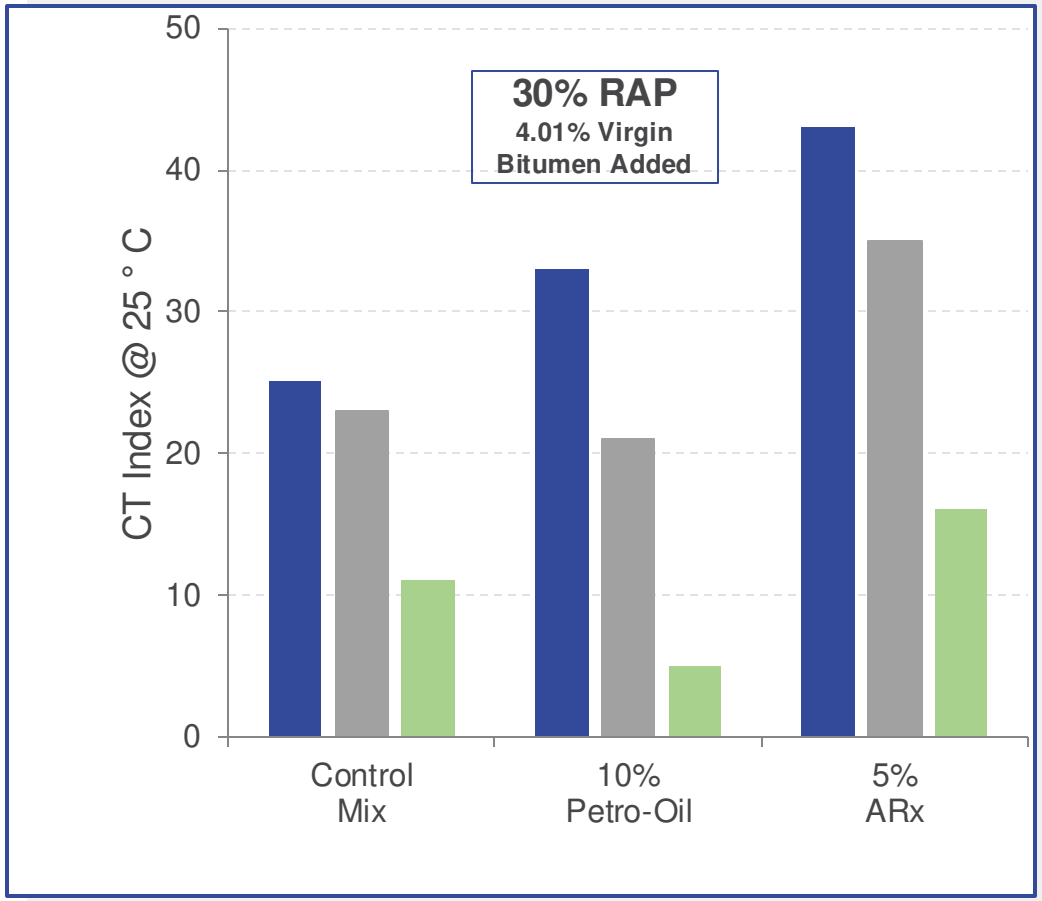
High RAP/RAS mixture Properties Incorporating Bio-oil (30 % RAP/5% RAS – 1 kg RA per tonne of mix)

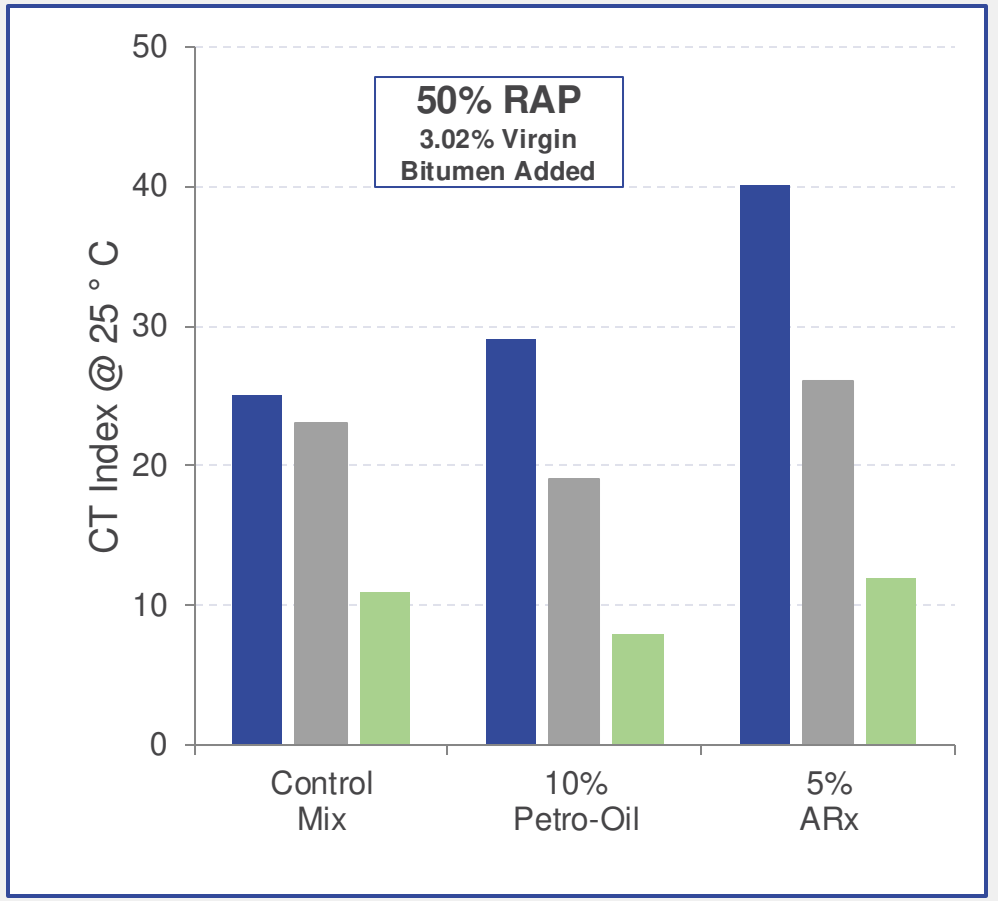
Property	Control Mix	High RAP/RAS +Bio Oil	Criteria
Air Voids, %	3.7	2.4	4.0
Texas Overlay, Number of Cycles	93	253	>150
APA Rutting, mm	5.4	6.3	<7.0

Illinois State Tollway Case Study

Property	PG 46-34 Mix*	PG 58-28 + AR_X (2.0% Tot AC) Mix	PG 58-28 + AR_X (3.6% Tot AC) Mix	Specification (Target)
DCT -12°C, J/m²	435	497	544	450
Hamburg, mm@20,000	6.34	8.70	8.77	12.5 @ 10,000
Voids, %	3.7	3.6	4.9	4.0
Total AC, %	6.0	6.1	5.8	6.1
Virgin AC added, %	4.3	4.0	3.7	-
AC Grade	PG 64-22	PG 64-22	PG 64-28	PG 64-22
ΔT_c, °C	-5.8	-5.4	- 3.7	-6.0
** One Grade Softer*				

Durability Profiles - Control vs High RAP mixtures Incorporating 2 Types of Recycling Agents



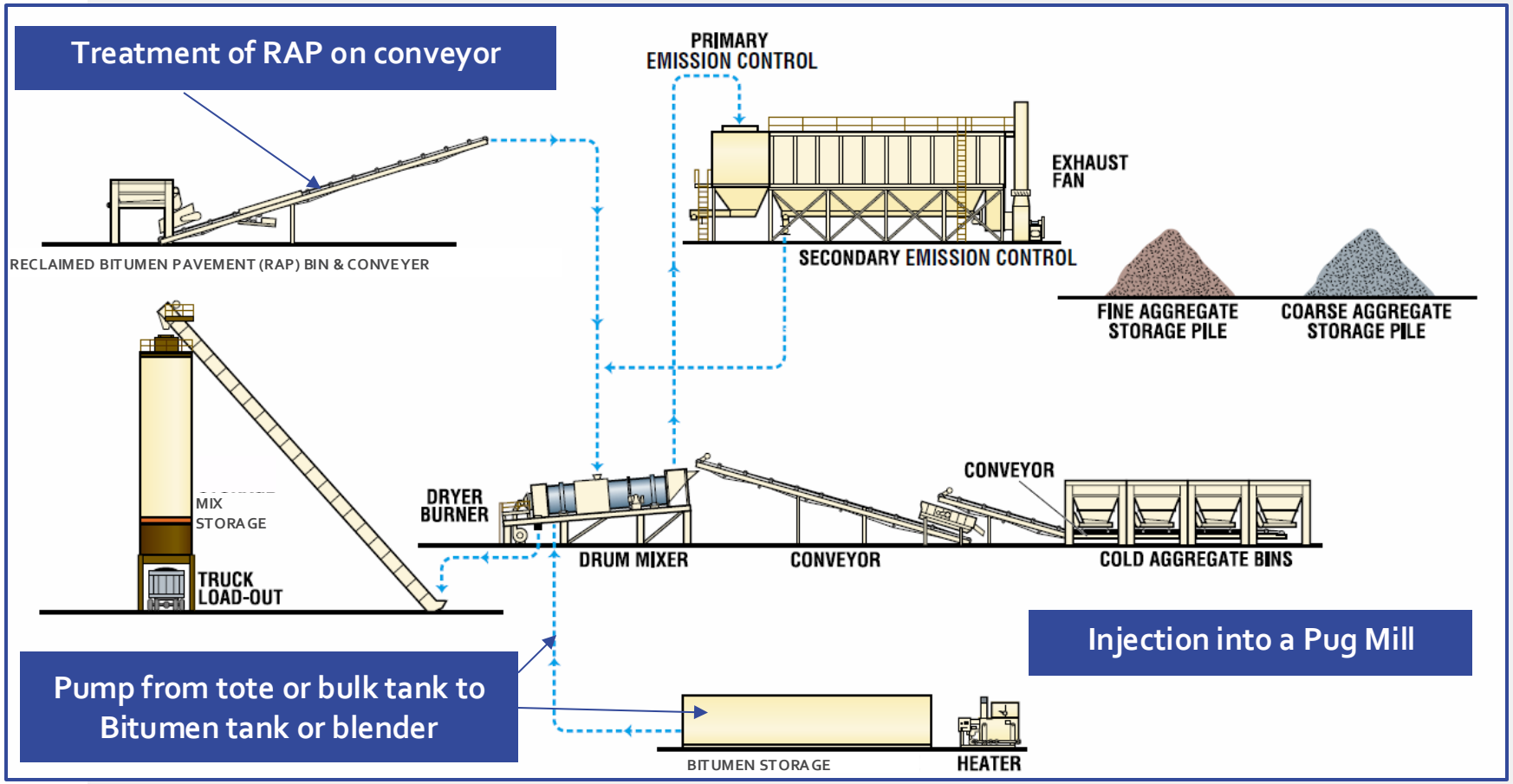


Aging Time
4 hrs.
8 hrs.
16 hrs.

Ongoing Research – Bio-Oil Trial Northern Virginia US

Continued monitoring of field performance critical – key implementation activity!

Incorporate ReLIXER® at a Mix Plant



Key Characteristics

- Environmentally Sustainable
- No Odor. No VOC
- Safe to Handle & Use
- High Flash Point
- Lower GHG
- Lower Carbon Footprint
- No Special PPE Required
- Non-Hazardous to Transport
- No Waste By-Products
- Stable at Mix, Use & Storage Temperatures
- Low Viscosity, Free Flowing

How Much RAP Can Your Plant Handle?
20 % RAP | 40 % RAP | 60 % RAP | 100 % RAP

In-Line Blending

SUMMARY OF FINDINGS & CONCLUSIONS

- ✓ Utilizing RAP/RAS in mixes is widely used and is considered a necessary practice.
- ✓ The performance of high RAP mixes can be equal to virgin mixtures if done properly.
- ✓ Well-Designed High RAP mixes are economical and sustainable.

SUMMARY OF FINDINGS & CONCLUSIONS

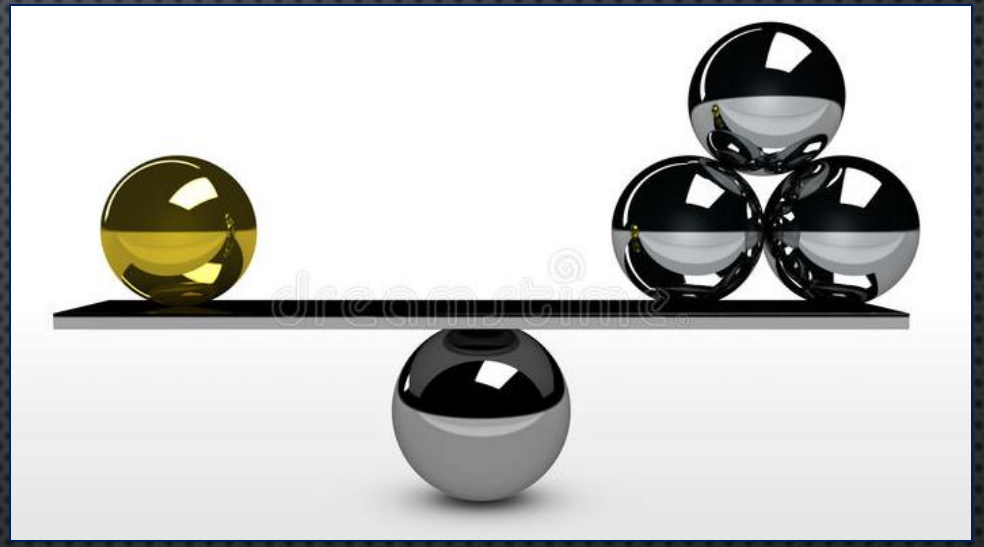
- ✓ Control of RAP is very important, treating and evaluating like any other input material is necessary.
- ✓ Binder Issues are very important; dosage rate and source of recycling agents are important for performance & cost of mixes with high RAP.
- ✓ Tools for successful and effective Balanced Mix Design (BMD) for high RAP mixes are available and Standardized.
  - ❖ Comparing critical cracking resistance, workability, and rutting to virgin mixes is a sound approach for gaining benefits of recycling.

HIGH RECLAIMED ASPHALT MIX: APPROACHES TO MIX DESIGN

For Greater than 25-30 % RAP a Rejuvenator or Recycling Agent is needed

BALANCED MIX DESIGN

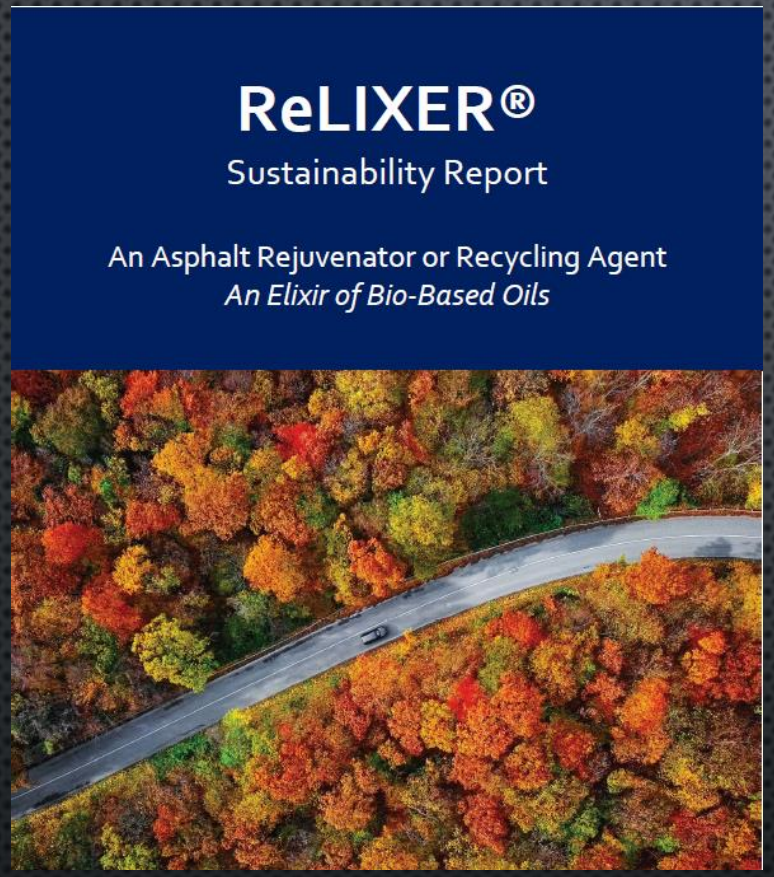
- Seek a balance between Rutting Resistance and Fracture Toughness
  - Rutting Resistance: Hamburg Wheel, APA, Cooper, French Wheel, Cantabro, etc.
  - Fracture Toughness: Overlay, SCB, SENB, I-FIT, DCT, Ideal CT, etc.



- Costs
- Potential Rutting
- Potential Cracking
- Potential Fatigue

With an Effective Rejuvenator, It Is Easy to Use High RAP Mixes

RELIXER®: ENVIRONMENTALLY-FRIENDLY BIO-BASED OILS



- Lower Energy Consumption
- Highly Dosage Efficient
  Less Additive Needed
- Lower Carbon Footprint
- Lower Greenhouse Gases
- Improved Roadway
  Performance & Durability
- Less Frequent Road Repair

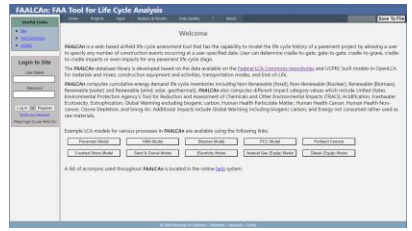
ReLIXER®: An Effective Bio-Oil Rejuvenator

AIRPORT INITIATIVES

- Evaluation of Balanced Mix Design (BMD)- Rutting & Cracking Tests
- Use of RAP in P-401Mixtures
- Validation of Gyratory for Airport Asphalt Mixtures
- Sustainability - LCA
- AAPTP Program – Collaboration is Key!

Environmentally friendly & sustainable pavement materials for airports

1. **Generating performance data** for recycled/sustainable materials under aircraft loading at the National Airport Pavement & Materials Research Center (NAPMRC).
2. **Completed evaluation of WMA**
   - Draft specification submitted to AAS-110 for review in FY23, and for subsequent inclusion in AC 150/5370-10.
3. **TC-3 at NAPMRC – Cold Central Plant Recycling (CCPR)**
4. Enhancing **international collaboration** (with France's DGAC).
   - Recycled Asphalt Pavement (RAP) & Bio-Binders – Received material samples from France. Testing expected to be completed by end of FY24.
5. Integrated LCA Commons data into **FAA's web-based Life Cycle Assessment (LCA) tool FAALCAn** to quantify environmental impacts of airport pavement construction projects. FAALCAn is the **only web-based tool available for life cycle assessment of pavements**.



Slide Courtesy of Navneet Garg - FAA

THANK YOU!

WWW.SRIPATH.COM

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