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Balancing Sustainability and Durability in Asphalt Pavements

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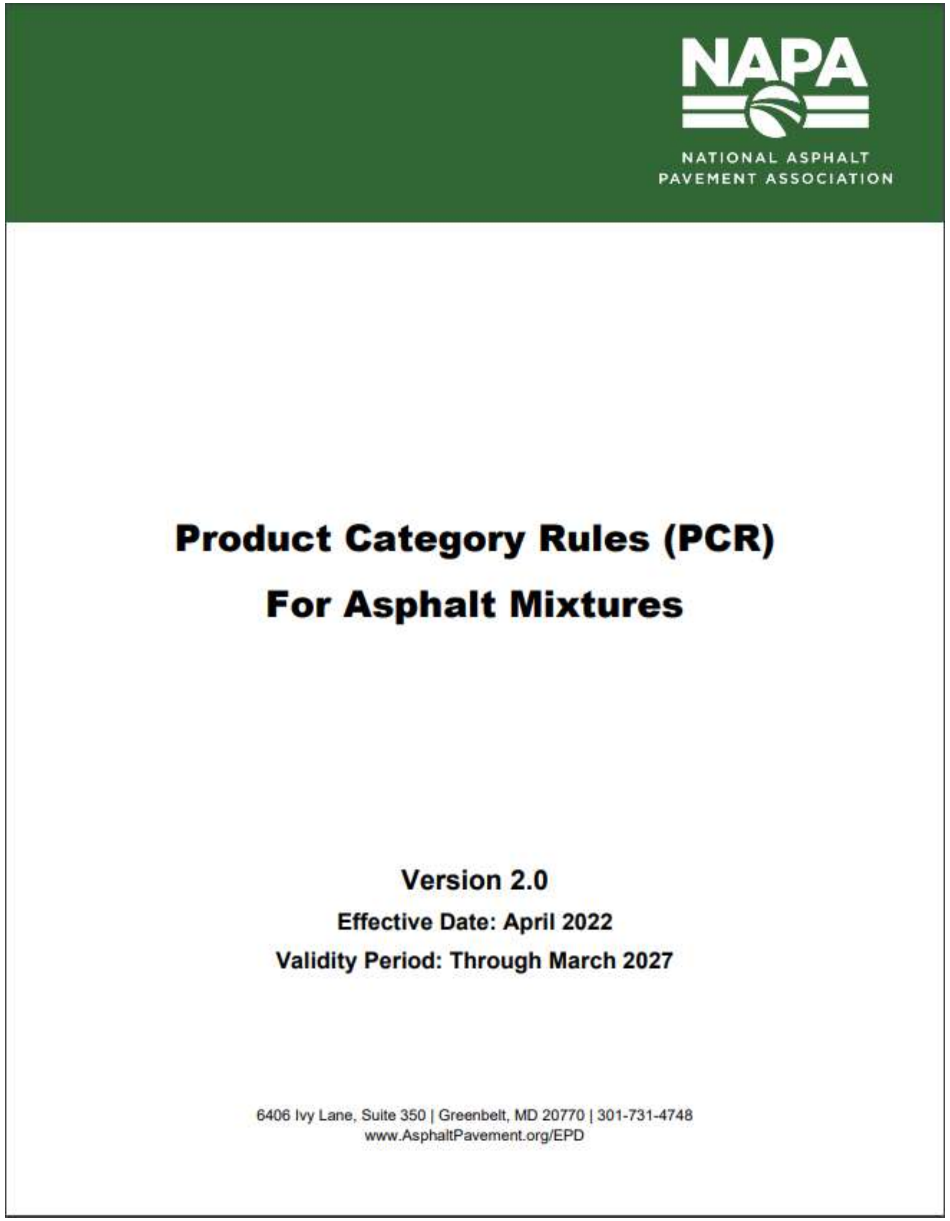
Defining Sustainability?

Environmental Product Declarations (EPD) System

- The environmental performance of the product shall be described from a life cycle perspective by carrying out a Life Cycle Assessment (LCA) of the product. The results of the LCA study and other information mandated by the reference Product Category Rules (PCR) and General Program Instructions shall be compiled in the EPD reporting format. The EPD shall then be verified by an approved independent verifier before being registered and published at the International EPD System via our EPD Portal. (The International EPD System)
- NAPA has published initial 2 versions of PCRs for Asphalt Mixtures (Through the Production Phase): AI Developing LCI (Inventorying for LCA for Asphalt Binders) in order to finalize PCRs for Asphalt Mixtures. (https://www.asphaltpavement.org/uploads/documents/EPD_Program/NAPA_PCR_AsphaltMixtures_v2.pdf)
- **LCAs are not LCCAs – Economic Cost or Cost Effectiveness is not part of the equation. LCAs are solely focused on impact to environment through life of mixture.**
- In US, Colorado and California have begun tracking EPDs (https://www.codot.gov/business/designsupport/materials-and-geotechnical/epd) (https://dot.ca.gov/programs/engineering-services/environmental-product-declarations)


NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

Product Category Rules (PCR)

For Asphalt Mixtures

Version 2.0

Effective Date: April 2022

Validity Period: Through March 2027

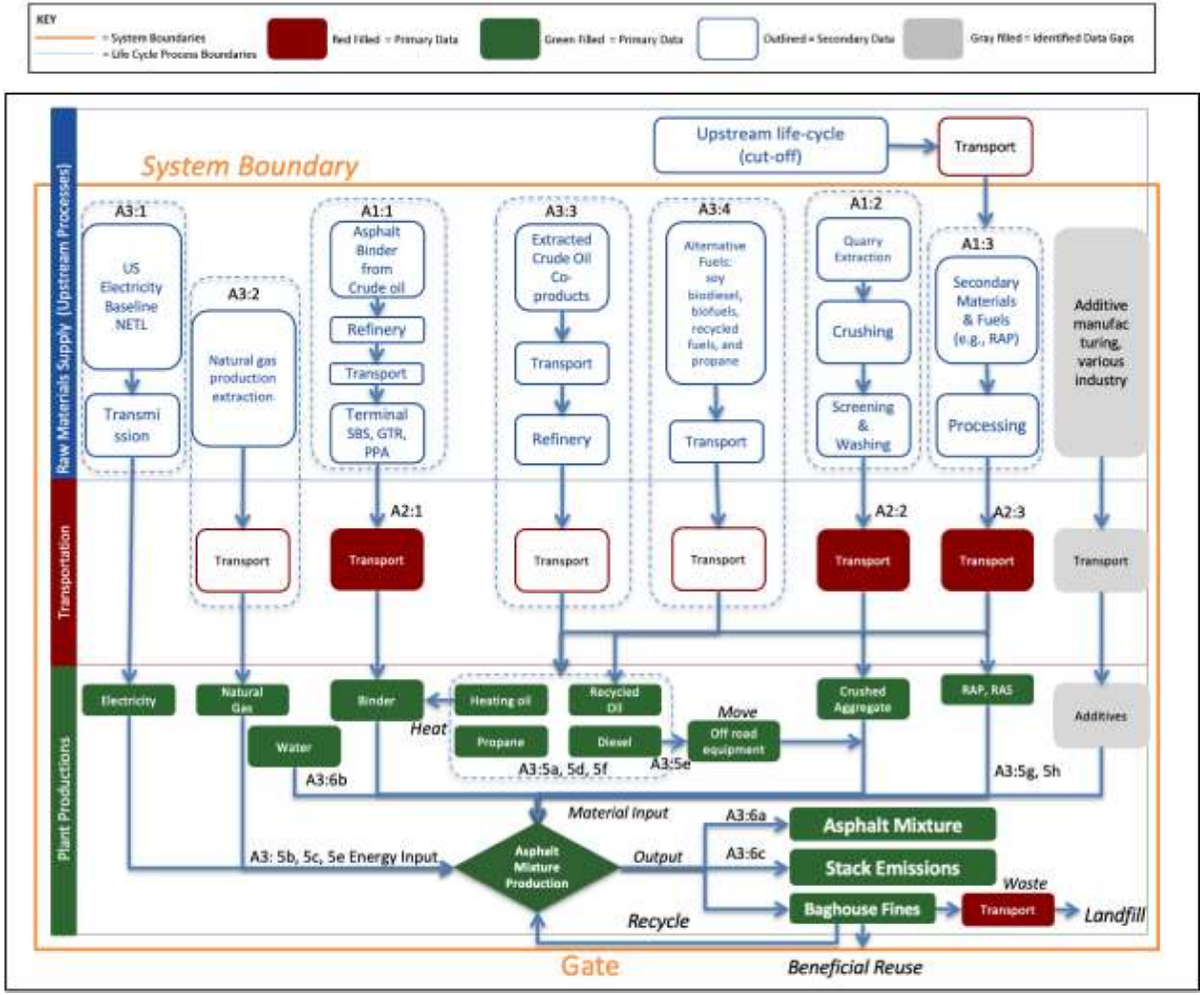
6406 Ivy Lane, Suite 350 | Greenbelt, MD 20770 | 301-731-4748
www.AsphaltPavement.org/EPD

PCR Example

Construction Works Assessment Information														
Construction Works Life Cycle Information Within the System Boundary														Optional supplementary information beyond the system boundary
A1-A3			A4-A5		B1-B7					C1-C4				
Production Stage			Construction Stage		Use Stage					End-Of-Life Stage				D
A1	A2	A3	A4	A5	B1	B2	B3	B4*	B5	C1	C2	C3	C4	
Extractional upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance (incl. production, transport, and disposal of necessary materials)	Repair (incl. production, transport, and disposal of necessary materials)	Replacement (incl. Production, transport, and disposal of necessary materials)	Refurbishment (incl. Production, transport, and disposal of necessary materials)	Deconstruction / Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste	Potential net benefits from reuse, recycling, and/or energy recovery beyond the system boundary
			Scenario	Scenario	Scenario	Scenario	Scenario	Scenario	Scenario	Scenario	Scenario	Scenario	Scenario	Scenario
					B6 Operational Energy Use Scenario									
					B7 Operational Water Use Scenario									

* Replacement information module (B4) not applicable at the product level

Figure 1. Common life cycle stages and their information modules for construction products and construction works. Life cycle stages included in this sub-category PCR are in the green box. Adapted from ISO 21930.



(From NAPA PCR For Asphalt Mixtures V. 2.0 Eff April 2022)

Sustainability Lowest Hanging Fruit for Asphalt Pavements

- **Recycled Asphalt Materials (RAM)**
    - Recycled Asphalt Pavement (RAP)
    - Recycled Asphalt Shingles (RAS)
  - 45MM Tons of RAP produced annually
  - 12MM Tons of Shingle Waste produced annually
  - Recycling Agent (Rejuvenator) Usage for boosting RAM levels in HMA with use of chemical agents

- **Production Temperature**
  - Warm-Mix and Cold-Mix Asphalt Technologies
    - Lower Hot-Mix Plant Production Related Fuel Consumption and Emissions

Defining Durability?

Specifications Developed in Response to Distress

Thermal Cracking

- Correlates most significantly with the binder properties

Rutting

- More related to mixture shear strength
- Binder can still contribute

Fatigue Cracking

- Affected by pavement structure and traffic
- PG Specs promote compliant/elastic binders

Photos from the MnDOT Website & Maintenance Manual

Specifications for Aggregate in Asphalt Mixes

- Dense Graded Aggregates: Interlocking between aggregate particles promotes strength
- Hard Aggregates: Prevent Polishing and/or breakdown under stress
- Rough-surfaced: Friction and surface area for bonding with Asphalt Binder
- Angular and Equidimensional (Cubical): Interlocking Aggregate Skeleton
- Rough Surfaced, Low Porosity, Hydrophobic and free of deleterious Substances: fight stripping, reduce absorption, and optimize friction and surface area, for bonding with Asphalt Binder

SUPERPAVE
Workbook: Step 1- Selection of Materials — Page 23

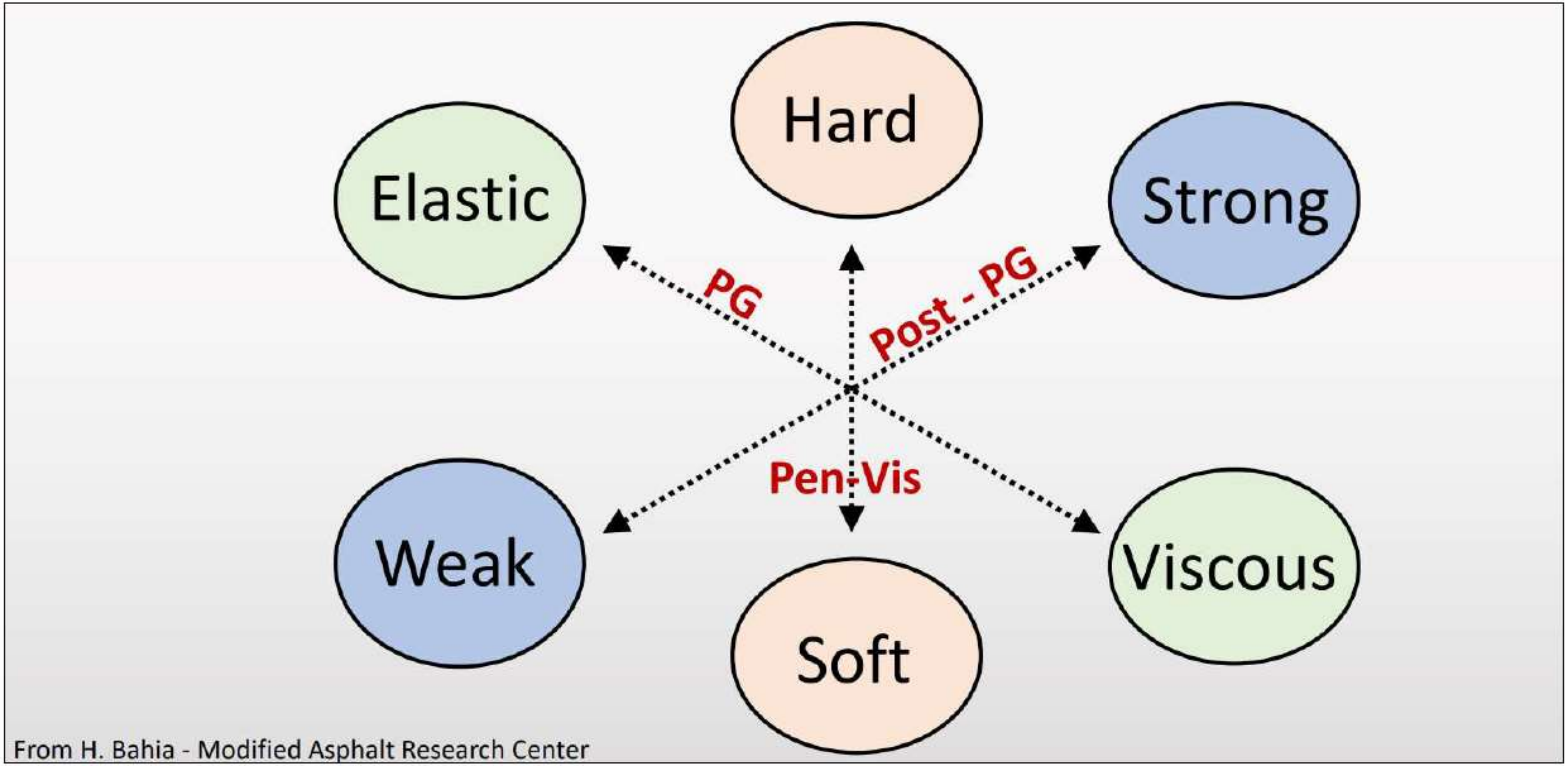
MP-2, Table 4 - Superpave Aggregate Consensus Property Requirements

Design ESALs[1] (million)	Coarse Aggregate Angularity (Percent), minimum — Depth from Surface		Uncompacted Void Content of Fine Aggregate (Percent), minimum — Depth from Surface		Sand Equivalent (Percent), minimum	Flat and Elongated[3] (Percent), maximum
	≤ 100 mm	> 100 mm	≤ 100 mm	> 100 mm		
< 0.3	55/-	-/-	-	-	40	-
0.3 to < 3	75/-	50/-	40	40	40	10
3 to < 10	85/80[2]	60/-	45	40	45	
10 < 30	95/90	80/75	45	40	45	
≥ 30	100/100	100/100	45	45	50	

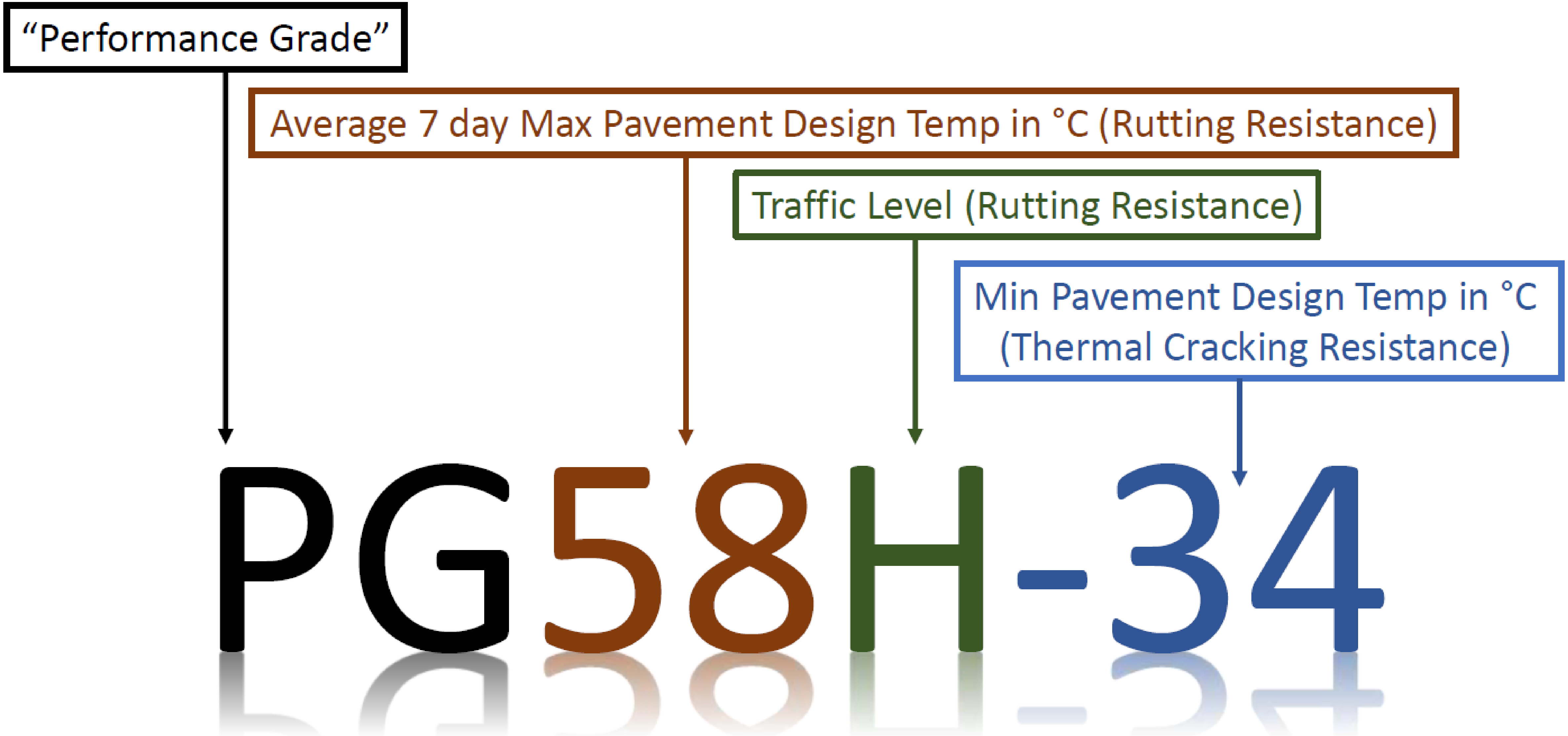
(1) Design ESALs are the anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years, and choose the appropriate N_{design} level.
(2) 85/80 denotes that 85 % of the coarse aggregate has one fractured face and 80 % has two or more fractured faces.
(3) Criterion based upon a 5:1 maximum-to-minimum ratio.

Note 5 - If less than 25% of a layer is within 100 mm of the surface, the layer may be considered to be below 100 mm for mixture design purposes.

Evolution of Specifications for Asphalt Binder



Current Binder Specification



Future/Additional Binder Specifications

Asphalt Parameters That Indicate Durability and Brittleness

Glover-Rowe

Cross-over Temperature

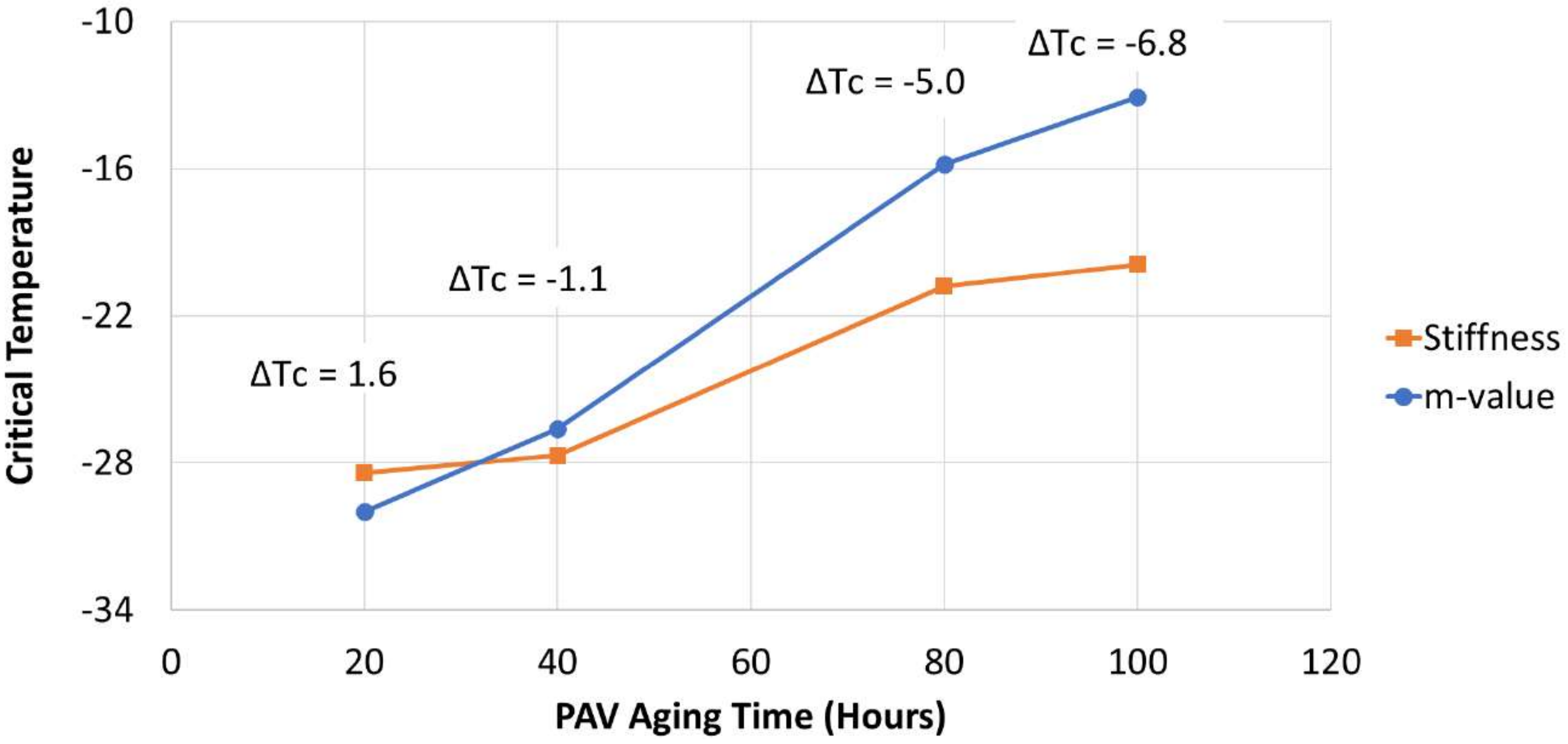
R-value

Phase Angle

ΔTc

What do we know about ΔTc?

- **As Binders Age, they lose ductility (Durability) and ΔTc Decreases**
- **ΔTc reaching -5.0 may be tipping point for age-related cracking**
- **We can measure this in the lab through aging process (PAV)**




Balancing Act?

RAM Limitations

- **RAP/RAS contains aged asphalt binder**
  - Binders become brittle with age
  - Durability determined by aged condition of asphalt
  - Less durable asphalts age faster

- **Plant Issues**
  - New equipment and parts required
  - Airspace for RAM Storage
  - Environmental Impact of handling processing RAP and RAS
  - Potentially higher HMA production temps

Balanced Mixed Design

(From NAPA BMD Resource Guide)

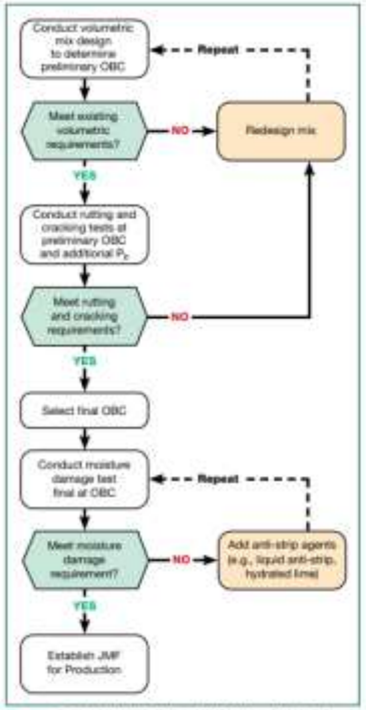


Figure 2. Graphical Illustration of the Volumetric Design with Performance Optimization Approach (Approach B)

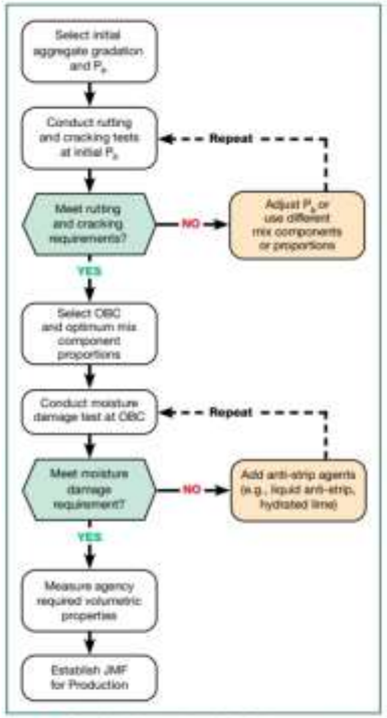


Figure 3. Graphical Illustration of the Performance-Modified Volumetric Design Approach (Approach C)

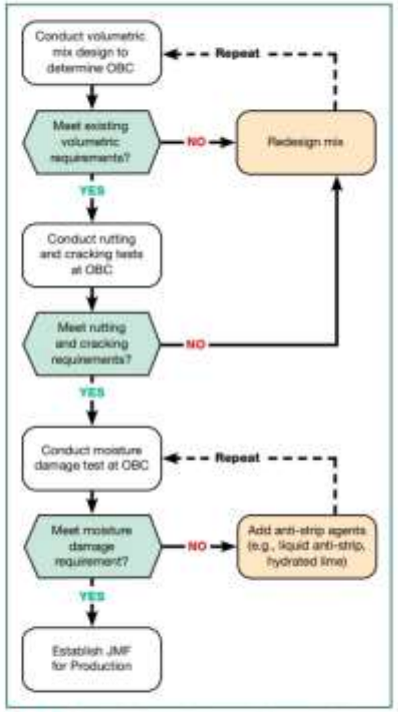


Figure 1. Graphical Illustration of the Volumetric Design with Performance Verification Approach (Approach A)

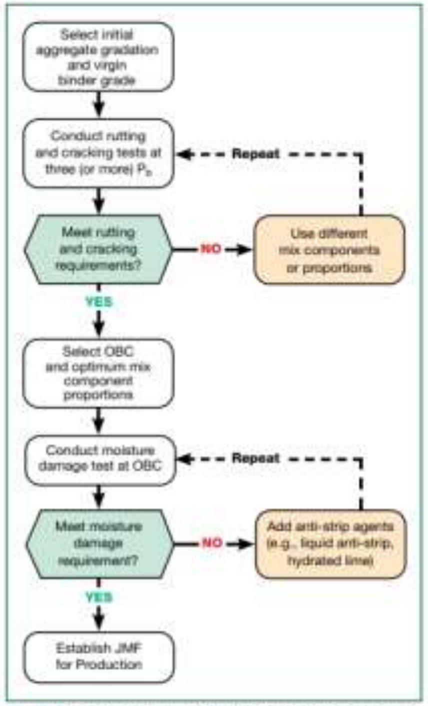


Figure 4. Graphical Illustration of the Performance Design Approach (Approach D)

Balanced Mixed Design

(From NAPA BMD Resource Guide IS-143)

Approach A
Approach C
Approach D
Approach A and D

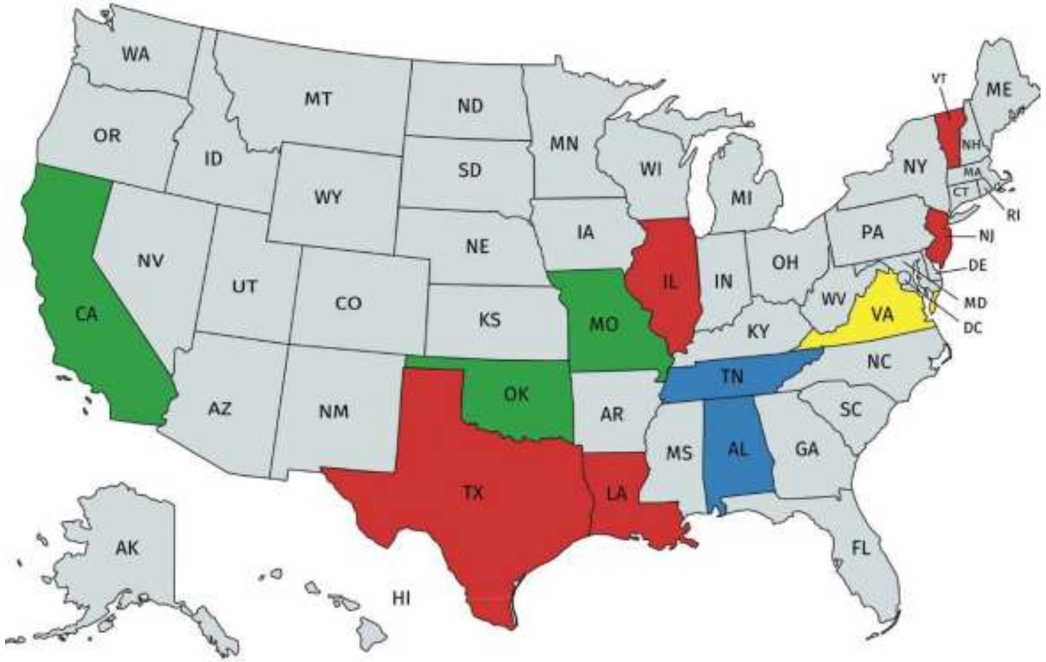
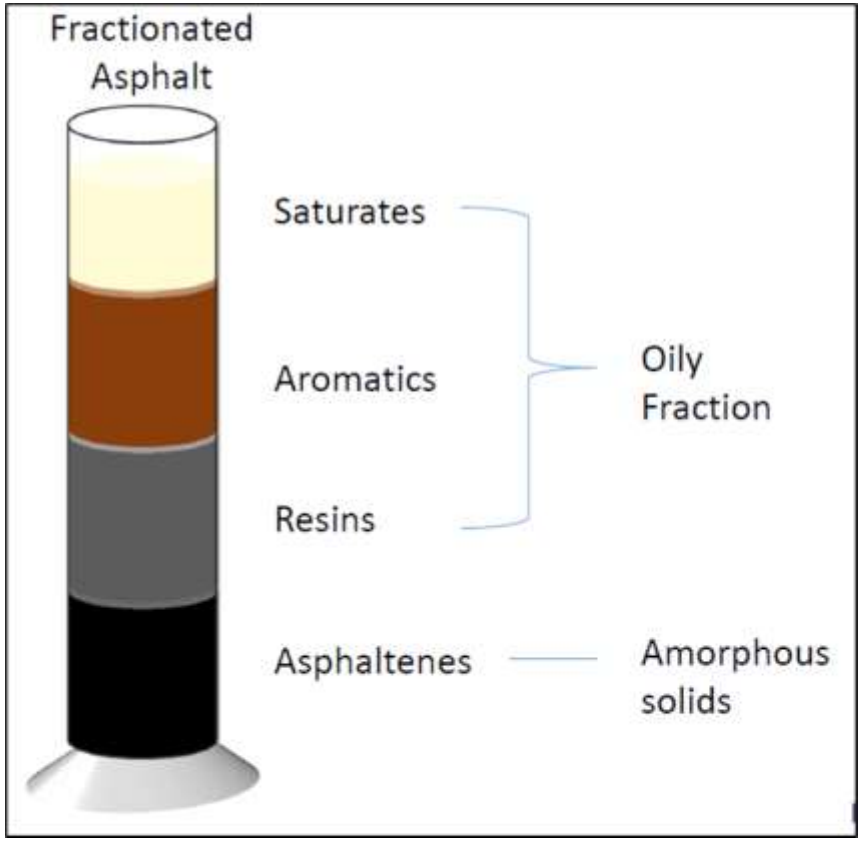


Figure 5. Map of SHAs with Draft, Provisional, or Standard BMD Specifications

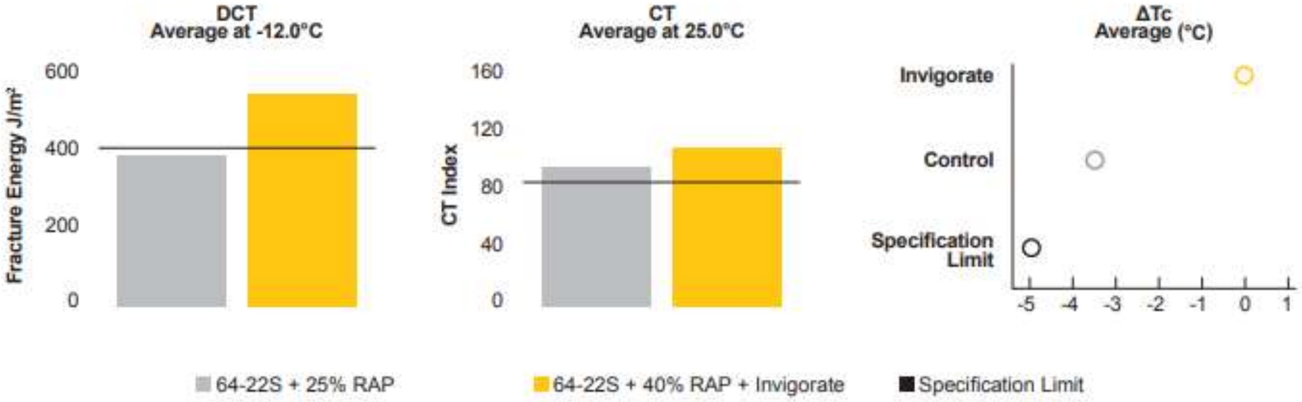
Recycling Agents to Boost RAP



- **Not all “Rejuvenators” are good**
  - VTAE/REOB, Aromatic Oils, even certain raw bio-oils can hurt durability through aging
  - **Effective Recycling Agents:**
    - Stabilize asphaltenes in oil fraction of asphalt
    - Restore viscoelastic properties, improve asphaltene mobility
    - Bio-based
  - **BETTER DURABILITY!**

Effective Recycling Agents

DATA FROM A PROJECT IN INDIANA



DATA FROM A PROJECT IN MINNESOTA

The Mix

58-28S Virgin Binder + **40%** RAP + **4%** Invigorate

The Results

58-28S Final PG

-0.7°C Final ΔTc

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USDA Certified Biobased Product 100%

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Warm-Mix Asphalt (WMA) Additives

- **Decrease Production Temperatures**
  - Lower Age Hardening of Binder
  - Decrease fuel consumption
- **Achieve Target Densities at Lower Ambient Air and Mix Temperatures**
  - Longer Hauls = Less Mobilizations
  - Longer Paving Seasons
  - Better Durability
- **Some WMA Technologies are also Recycling Agents, resulting in more durable mixes**

Table 2: Performance Test Results

BIT #	Additive (Mixing Temp)	Additive Dosage Rate (%)	Hamburg (5,000 passes)	Hamburg (10,000 passes)	Hamburg (15,000 passes)	Hamburg (20,000 passes)	IFIT	Ideal CT
2312004	None (320F)	N/A	-3.19	-4.55	-6.60	-9.51	10.3	130.9
2312007	Invigorate (320F)	1.0	-2.90	-4.15	-6.58	-12.5 @ 19,950 passes	16.7	152.8
2312008	Invigorate (270F)	1.0	-3.37	-4.62	-7.03	-12.5 @ 18,550 passes	16.0	174.9
2312009	Invigorate (320F)	0.5	-3.15	-4.37	-5.93	-8.88	9.0	128.7

Cold-Mix Asphalt (CMA) Pavements Innovations

THE THREE-STEP PROCESS

STEP 1

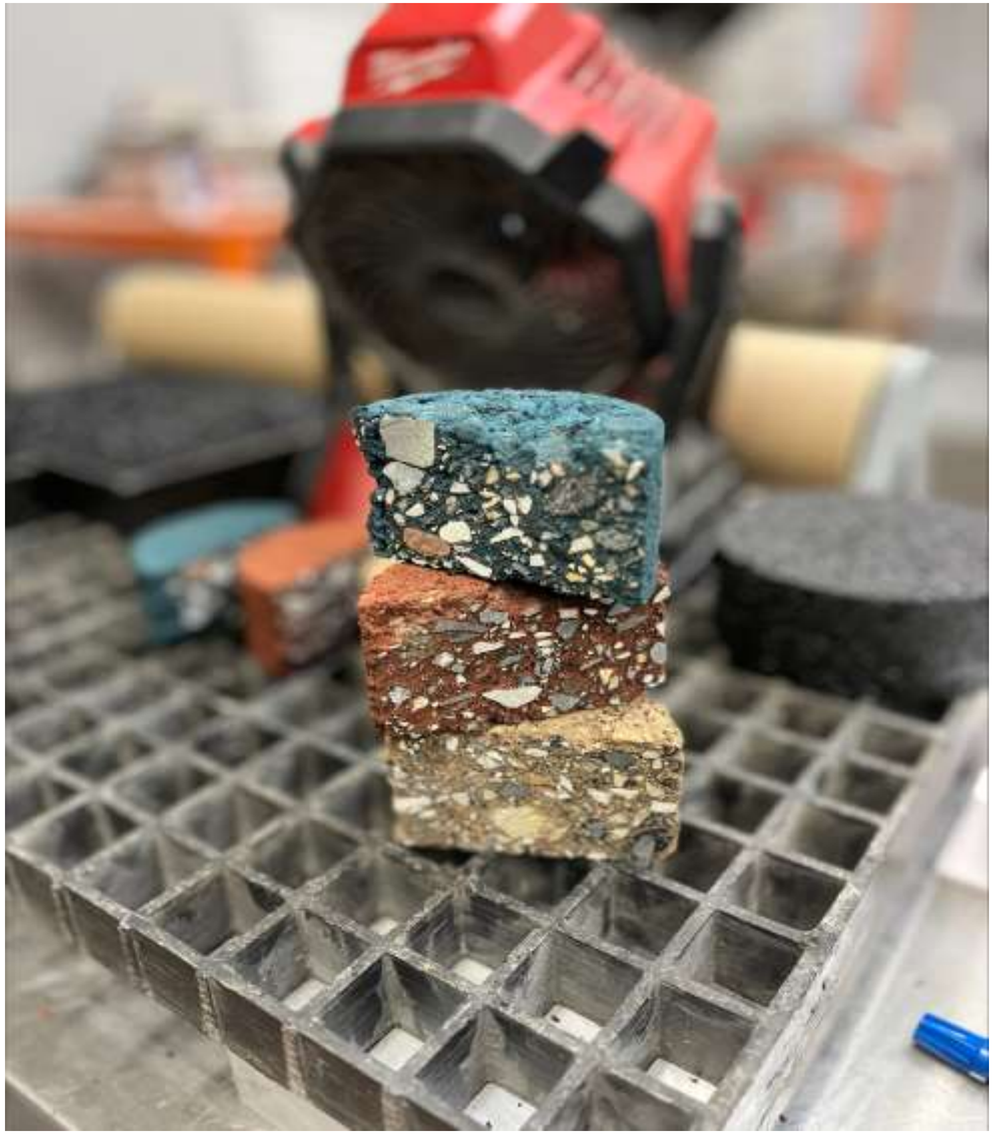
Spread asphalt millings evenly across the desired surface area and spray Invigorate Plus on the loose millings.

STEP 2

Compact the treated millings to form the new surface. Before and after compaction, Invigorate Plus travels throughout the recycled material, binding the pore structure and sealing the surface.

STEP 3

Let the surface cure for two weeks. You can continue to use the surface as it cures — and Invigorate Plus will continue to clean up any remaining signs of aging at the same time.



Recap/Conclusions:

- **Current Sustainability pushes not focused on durability, but on ‘Environmental Performance’**
- **EPD usage, though not thoroughly defined, will be a lasting part of road construction in the future**
- **Asphalt binder and aggregate specifications are developed and updated to address durability concerns**
- **Current specifications do not directly fit into sustainability focuses, particularly in low bid environment.**
- **Balance Mix Design and the use of proper additives can bridge gap between Sustainability and Durability**
- **Owners can replace some volumetrics with performance testing, avoiding cost increases/spec creep**
- **Existing technologies/methodologies allow industry to address both sustainability and durability concerns.**

Questions?

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