Asphalt Pavement Initiatives

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PA Asphalt Pavement Association

July 31, 2024

PennDOT – PAPA Bus Tour

District 5: Allentown, PA

Topics

- SMA
  - History
  - What it is
  - How to use it
  - Innovations
  - Recent Spec Changes
- Other Initiatives
  - BMD
  - EPDs

Stone Matrix Asphalt (SMA)

SMA

"A gap graded aggregate-asphalt hot mix that maximizes the asphalt cement content and coarse aggregate fraction. This provides a stable stone-on-stone skeleton that is held together by a rich mixture of asphalt cement, filler, and stabilizing additive"

~ FHWA SMA TWG (Brown and Manglorkar, 1993)

- Mix description:
  - Binder rich mortar
    - Modified binder (6-7%)
    - Stabilizing agents:
      - WMA additive or Crumb Rubber
      - Mineral or Cellulose Fiber (8-12%)
  - Gap-graded aggregate structure
    - 70-80% coarse aggregate

Image source: The Asphalt Pro, How to Pave Fibreless SMA

SMA

- Developed in Germany in late 1960s
  - Intent: develop a mix with better resistance to studded tires
    - Aggregate skeleton provides shear resistance
- Introduced to US in 1990s: EAST
  - FHWA SMA TWG to evaluate
    - aggregate type,
    - binder source and grade,
    - environmental conditions,
    - production and
    - construction methods

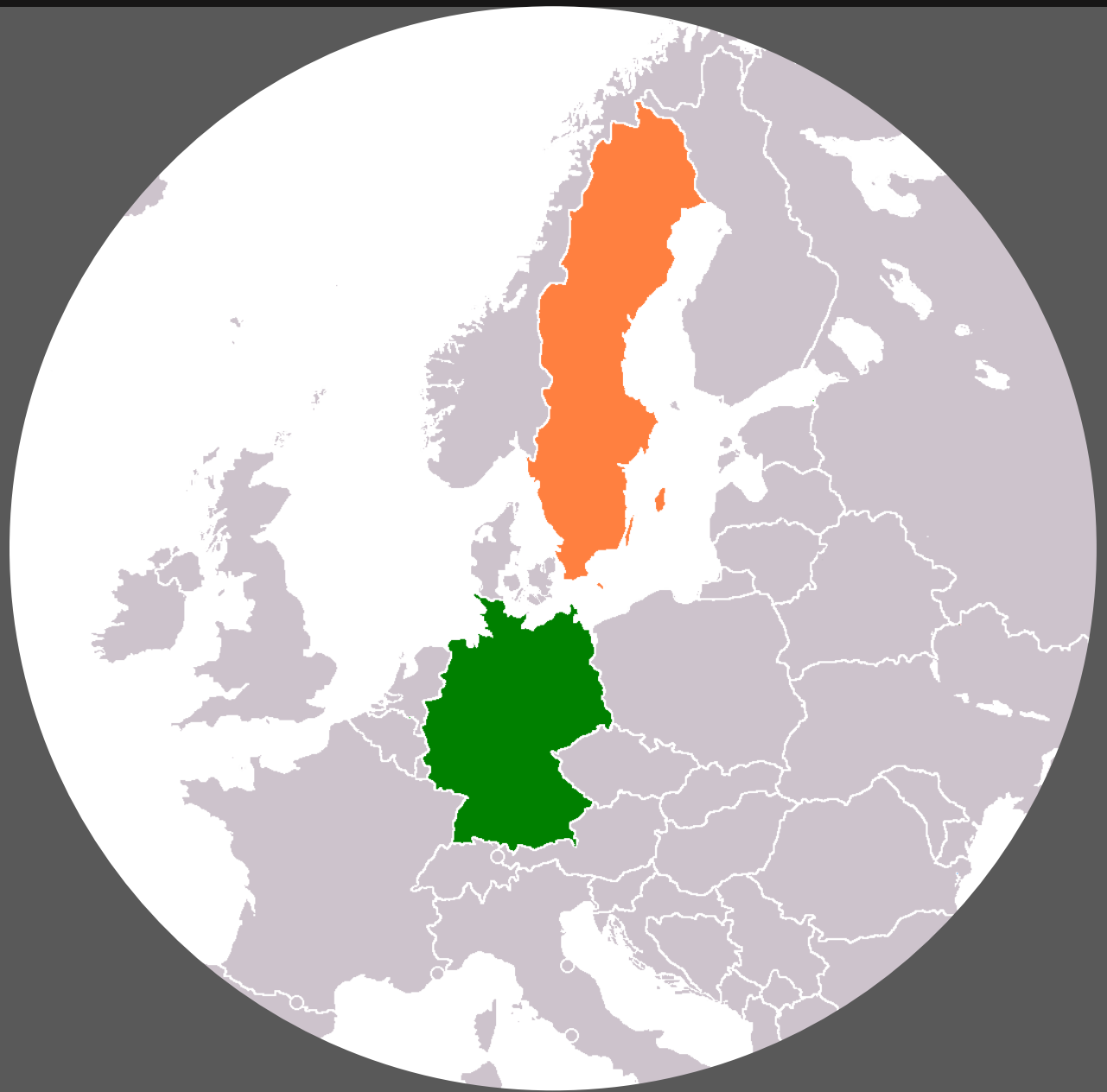
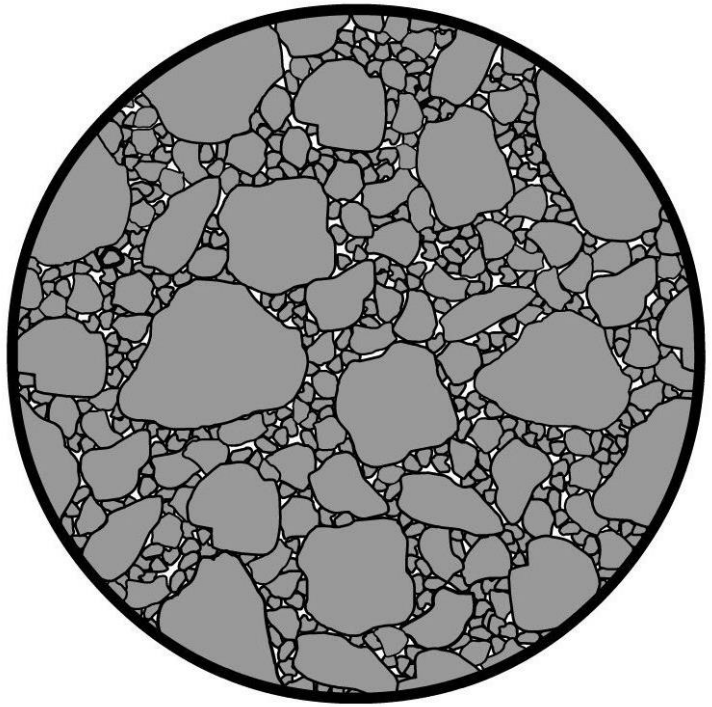


Image source: Wikipedia

SMA vs Dense Graded Superpave

Which one is the SMA? A or B

A



B

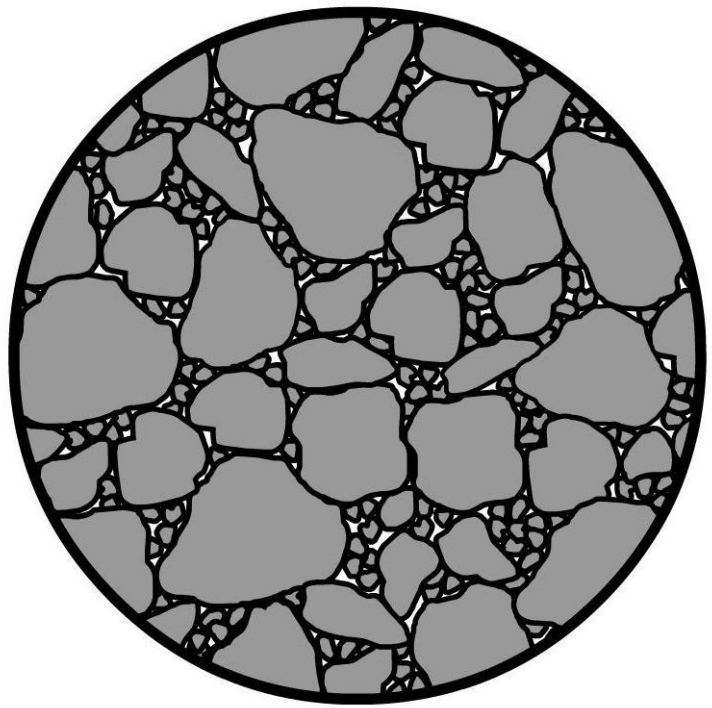
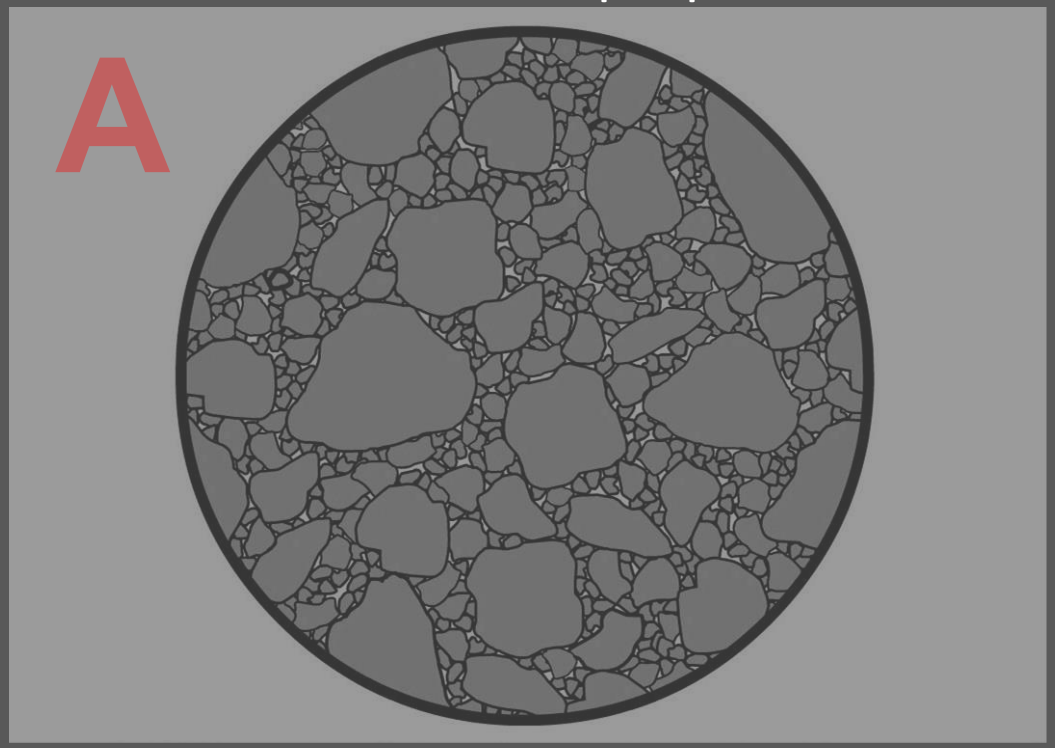


Image source: Pavement Interactive

SMA vs Dense Graded Superpave

Which one is the SMA? B

Dense Graded, Superpave Mix



Stone Matrix Asphalt Mix

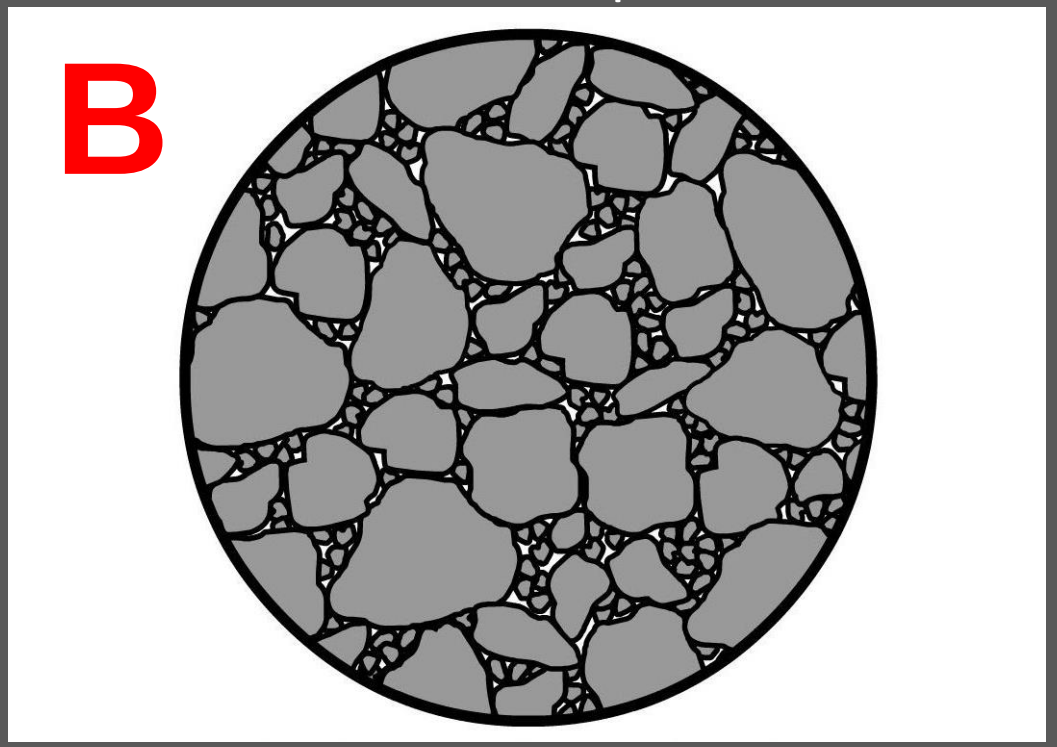
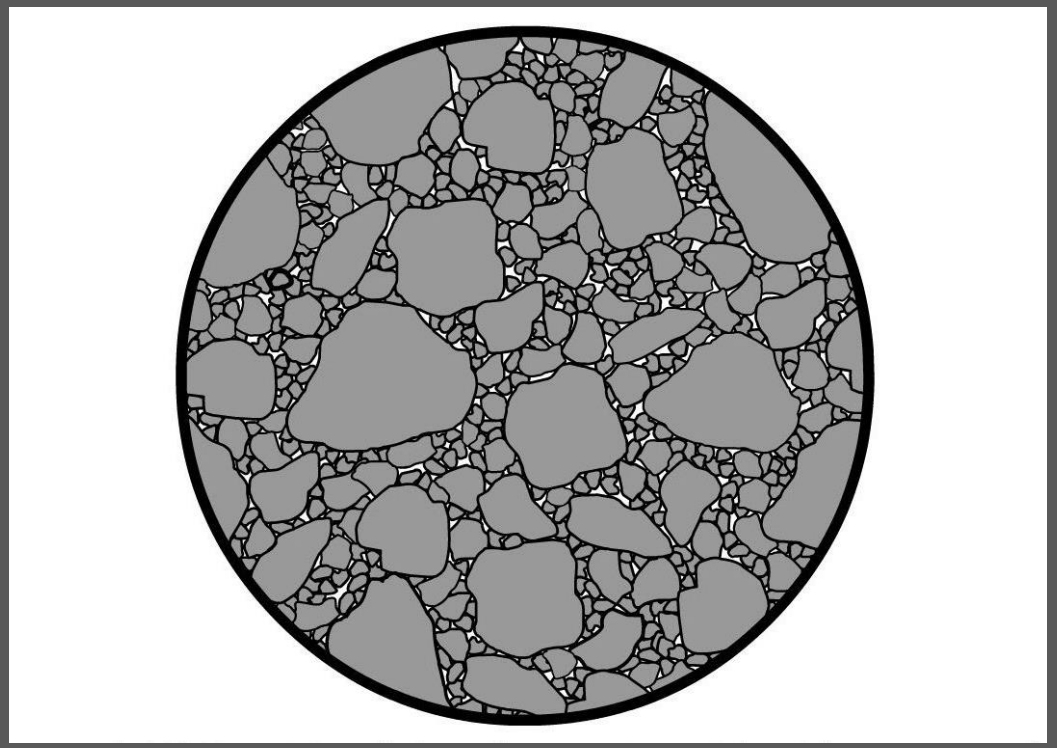


Image source: Pavement Interactive

SMA vs Dense Graded Superpave

Dense Graded, Superpave Mix



Stone Matrix Asphalt Mix

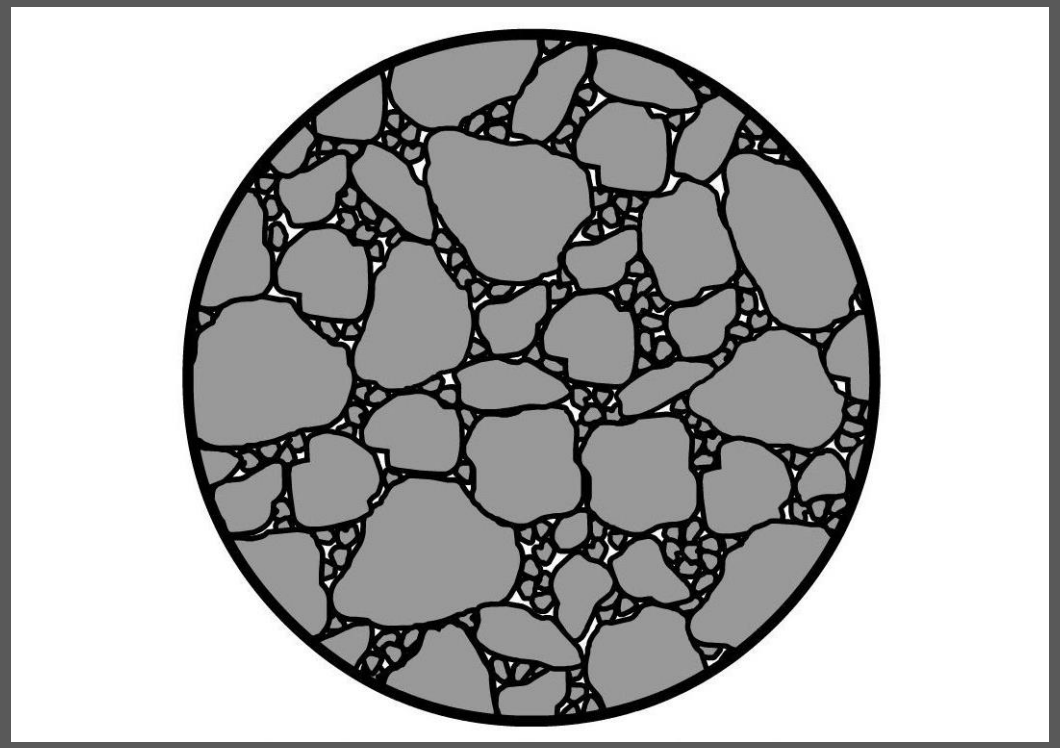


Image source: Pavement Interactive

SMA vs Dense Graded Superpave:

Mix design considerations

Dense Graded, Superpave

- Fine or coarse graded

- VMA: 11% to 17%
- Binder Content: 4.5% to 6%
- Air voids: 4%

Stone Matrix Asphalt

- Voids in Coarse Aggregate (VCA)
  - Cubical, low abrasion
  - Crushed stone and manufactured sand
- Higher VMA: 17% +
- Higher Binder Content: 6% +
- Air voids: 4%
- Draindown

Image source: The Asphalt Pro, How to Pave Fibreless SMA

SMA vs Dense Graded Superpave:

Mix design considerations

- Voids in Coarse Aggregate (VCA)
  - Increase in VCA -> mix gets finer
  - Lower VCA provides more stone-on-stone contact

$$VCA_{DRC} = \left[\frac{(G_{ca} \times \gamma_w) - \gamma_s}{G_{ca} \times \gamma_w}\right] \times 100$$

$$VCA_{mix} = 100 - \left[\left(\frac{G_{mb}}{G_{ca}}\right) \times P_{bp}\right]$$

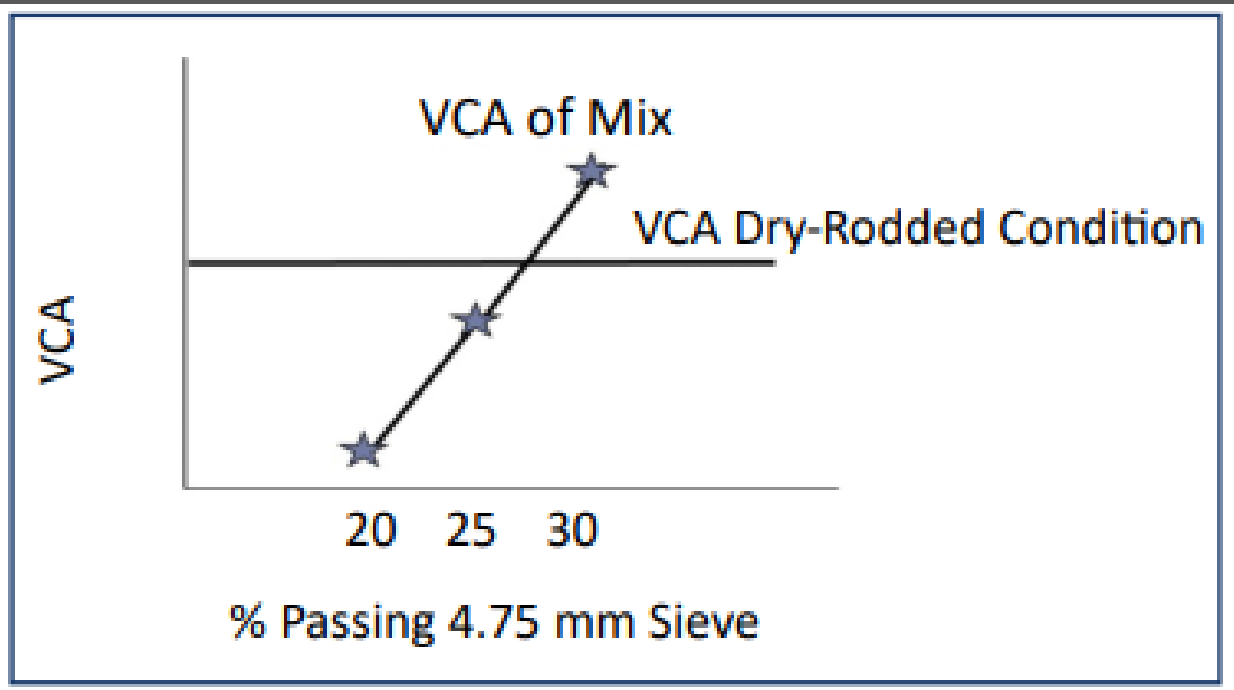


Figure 5: VCA of mix versus VCA of dry-rodded aggregate. (Source: NCAT)

SMA Benefits

- Extended Performance Life
- Rut Resistance
- Improved Durability
- Improved friction
- Reduced Noise

Image source: The Asphalt Pro, How to Pave Fibreless SMA

SMA Benefits

- Extended Life: Flexible Pavements

Table 3. Predicted Service Life for Flexible Pavement (Yin and West, 2018).

Highway Agency	Performance Measure	Predicted Service Life (Years)	
		SMA	Superpave
Alabama DOT	Pavement Condition Rating (PCR)	16.2	16.6
Colorado DOT	Rutting Fatigue Cracking Transverse Cracking Longitudinal Cracking	17.0	17.4
Georgia DOT	PACES Rating	16.0	11.0
Maryland SHA (Interstate)	Rutting Cracking Index (CI)	24.8	26.9
Maryland SHA (Principal Arterial)	Rutting Cracking Index (CI)	32.2	24.0
Minnesota DOT	Ride Quality Index (RQI) Surface Rating (SR)	16.6	11.3
Virginia DOT	Critical Condition Index (CCI)	19.0	14.4

Source: Yin and West, NCAT Report 18-03

SMA Benefits

- Extended Life:
  Composite Pavements

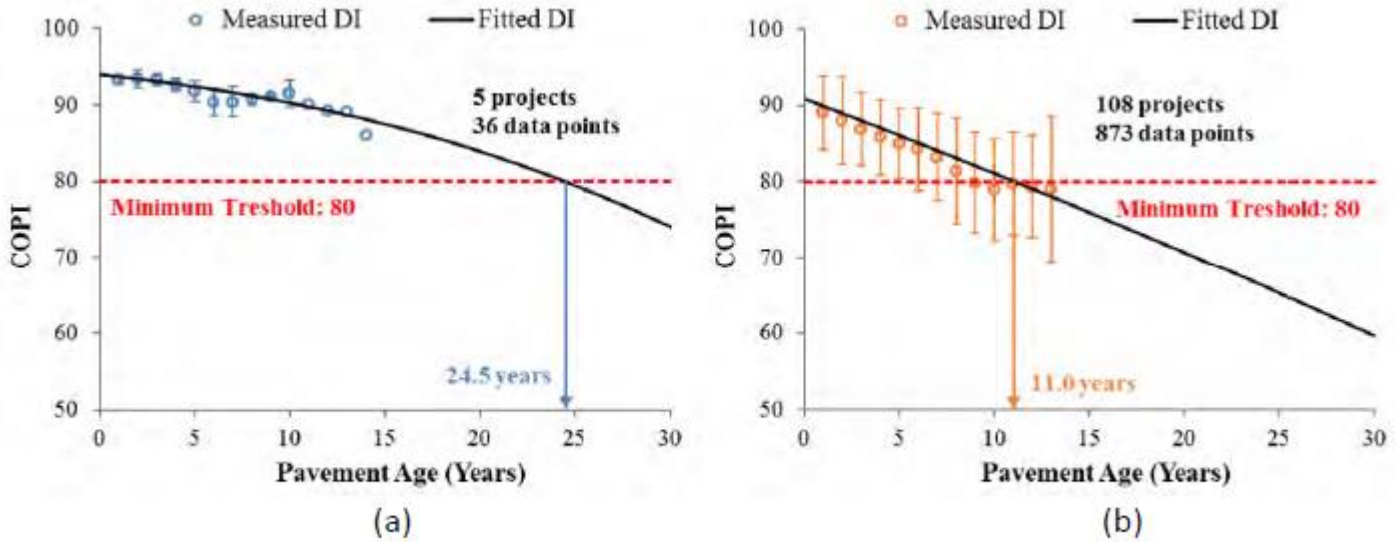


Figure 14. Pennsylvania DOT OPI Data of Composite Pavements on NHS Non-Interstate Routes; (a) SMA, (b) Polymer-Modified Superpave Mixtures

Table 4. Predicted Service Life for Composite Pavement (Yin and West, 2018).

Highway Agency	Performance Measure	Predicted Service Life (Years)	
		SMA	Superpave
Illinois Tollway	Overall Condition Rating Survey (CRS)	13.5	9.0
Maryland SHA (Principal Arterial)	Rutting Cracking Index	21.8	19.6
Michigan DOT	Overall Distress Index (DI)	22.2	21.3
Pennsylvania DOT (Interstate)	Overall Pavement Index (OPI)	21.1	22.2
Pennsylvania DOT (Non-Interstate)	Overall Pavement Index (OPI)	24.5	11.0
Virginia DOT	Critical Condition Index (CCI)	23.1	12.8

Source: Yin and West, NCAT Report 18-03

SMA Benefits

Improved Friction

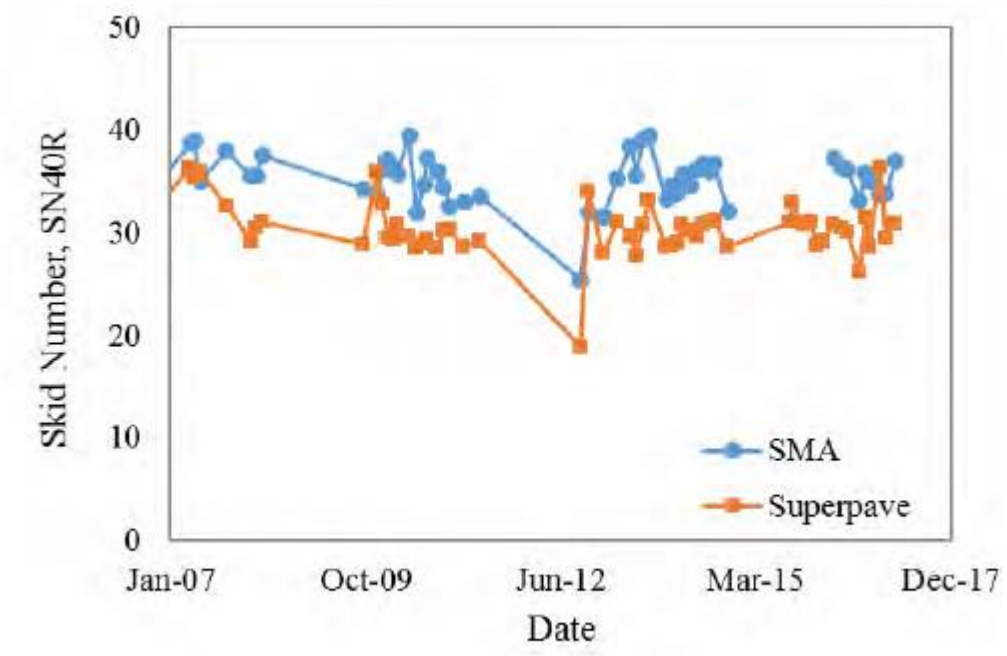


Figure 41. Surface Friction Comparison of NCAT Test Track SMA and Superpa

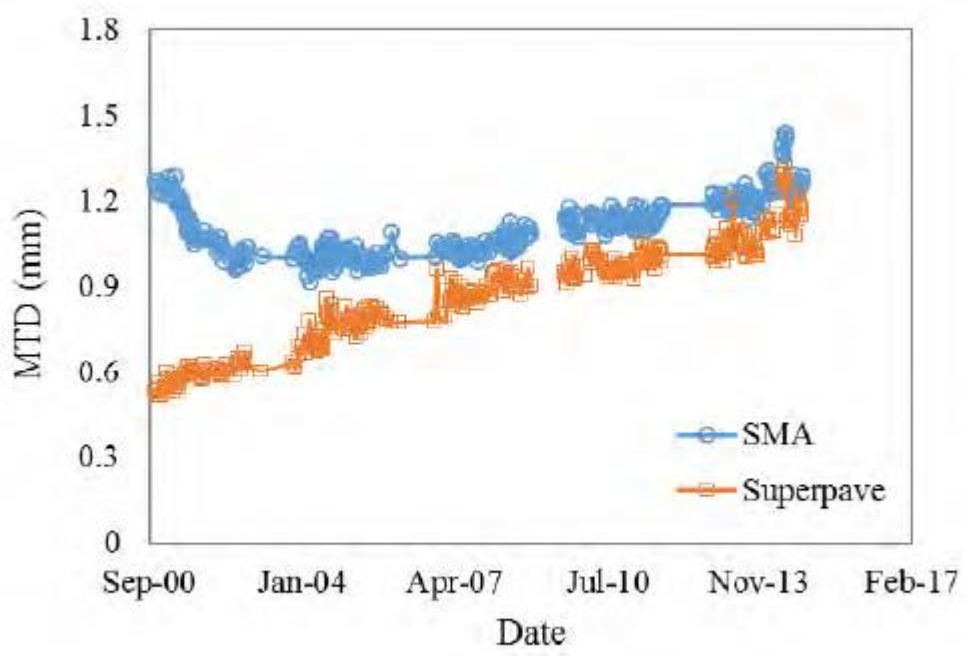


Figure 40. Macrotexture Comparison of NCAT Test Track SMA and Superpave Sections

Source: Yin and West, NCAT Report 18-03

SMA Benefits

Reduced Noise

Table 6. Comparative Noise Levels of Different Pavement Surface (Kandhal, 2004).

Pavement Surface Type	Comparative Noise Level (dB(A))
Open Graded Friction Course (OGFC)	–4
SMA	–2
Dense-graded Asphalt	0 (reference)
Portland Cement Concrete	+3

Source: Yin and West, NCAT Report 18-03

SMA - Where

SMA - Where

Table 1. Survey Responses of SMA Mixture Selection Policy

Highway Agency	Survey Response
Alabama DOT	Projects with 20-year design traffic greater than 30 million equivalent single axle loads (ESALs); projects with rutting concerns (such as intersections).
Colorado DOT	No criteria, but typically used on projects with high traffic volumes.
Georgia DOT	State and interstate routes with ADT greater than 50,000; state routes with ADT between 10,000 and 50,000 only when recommended by Office of Materials and Testing.
Illinois DOT	Projects with ADT greater than 35,000.
Illinois Tollway	All mainline pavements.
Indiana DOT	Decision by the Pavement Designer.
Kansas DOT	Project-by-project decision, but rarely used.
Maryland State Highway Administration (SHA)	Projects with 20-year design traffic greater than 30 million ESALs; projects with a functional class of Principal Arterial or greater.
Michigan DOT	Projects with 20-year design traffic between 10 and 100 million ESALs.
Minnesota DOT	No criteria, but typically used on projects with high traffic volumes.
Missouri DOT	Interstate routes and other freeways.
Pennsylvania DOT	Interstates, interstate look-alike highways, and high-speed freeways; projects with a minimum quantity of 50,000 square yards; roadways with greater than 30 million ESALs.
South Dakota DOT	Most four-lane roads and interstate routes.
Utah DOT	No criteria, but typically used on interstate routes.
Virginia DOT	Projects with greater than 3 million ESALs; Heavy to extreme heavy traffic volume routes where the higher cost can be justified with improved performance over other mixtures.
Wisconsin DOT	Projects with 20-year design traffic greater than 5 million ESALs; Projects where low maintenance is beneficial (such as high-traffic areas); Projects where SMA is economically feasible.

SMA - Where

PennDOT Pub 242: Dos

- > 100,000 SY recommended
  - Cost prohibitive for < 50,000 SY
- > 30 Million ESALs

PennDOT Pub 242: Don’ts

- Avoid where a lot of handwork is required (e.g. intersections, driveways)
- Stop-gap fix

Innovations in SMA

SMA with RAP

- Background
  - States allowing RAP in SMA (as of 2018):
    Yin and West, NCAT Report 18-03

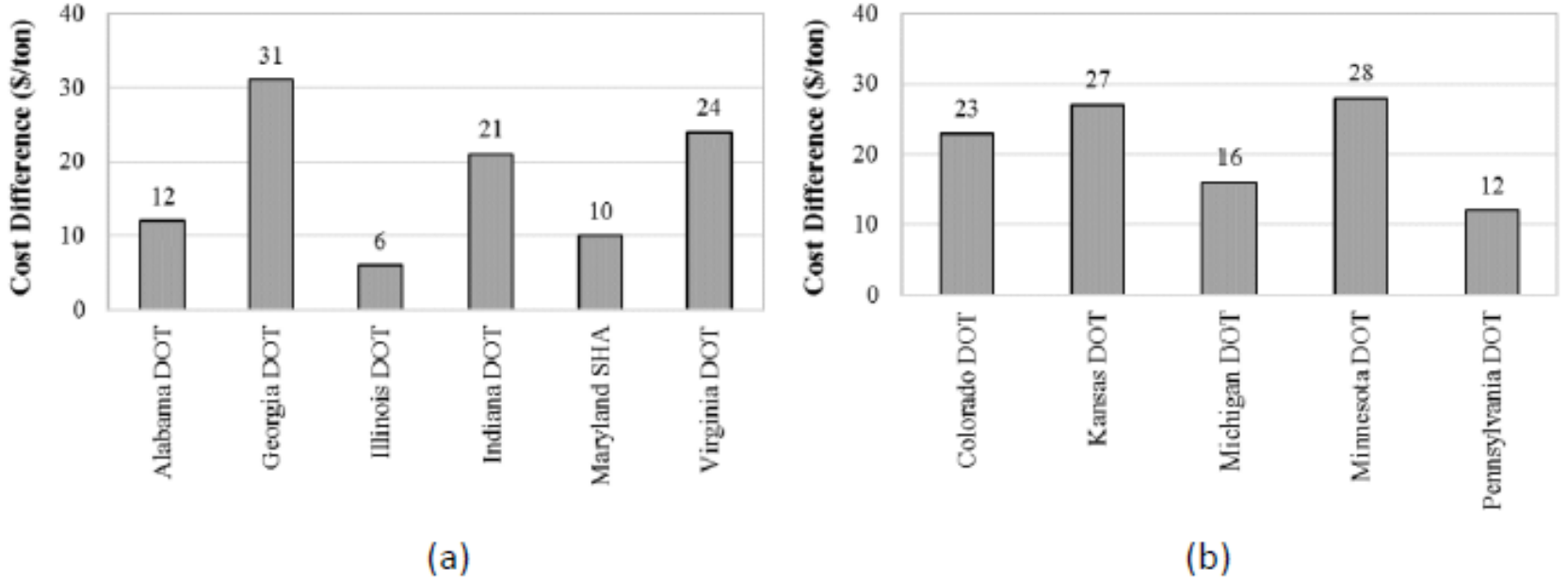
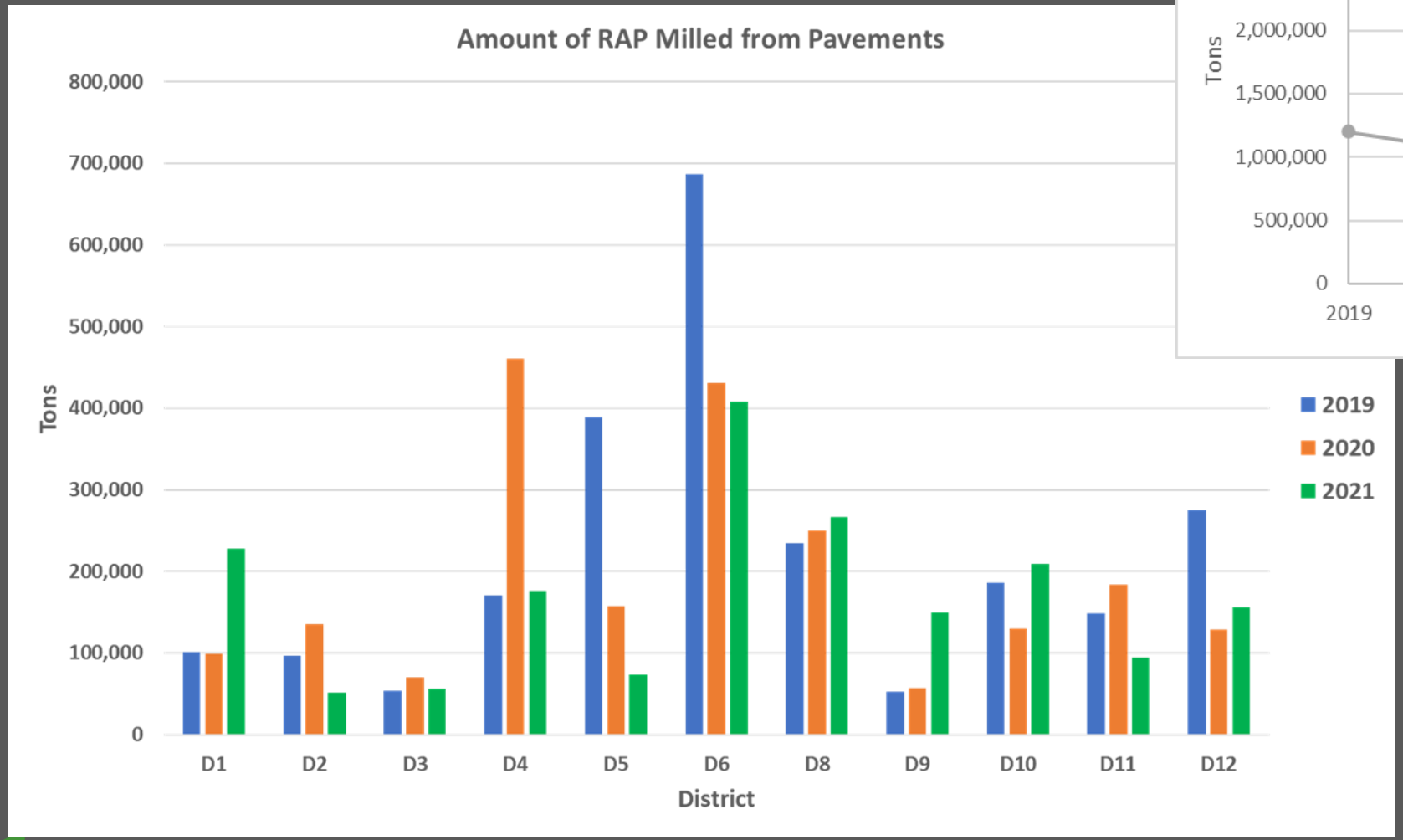


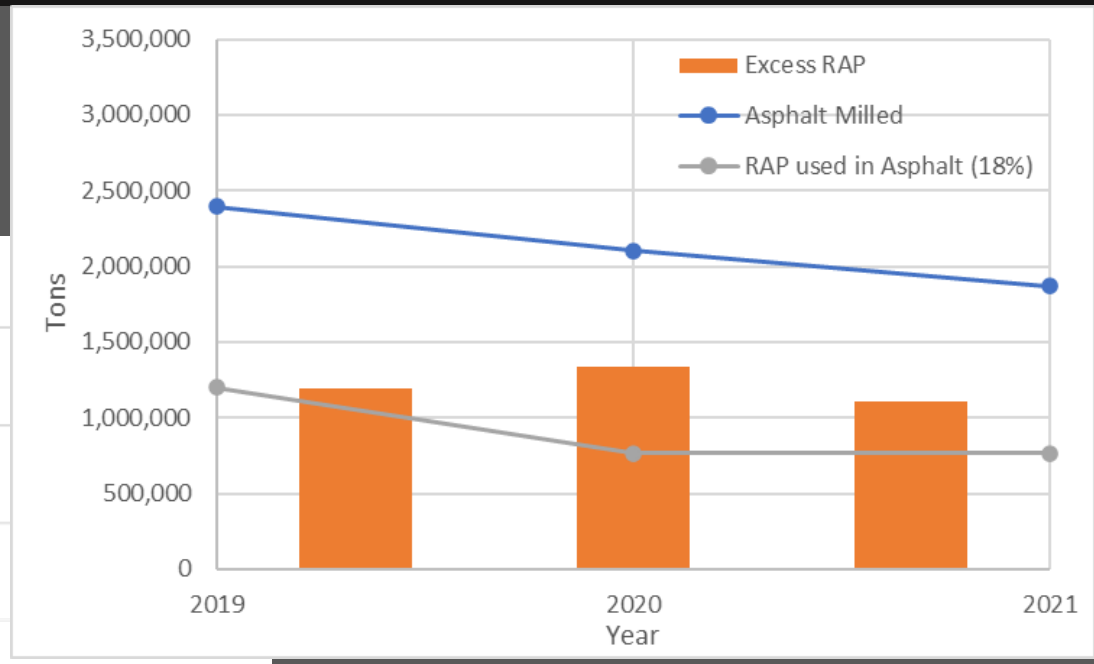
Figure 5. Difference in Weighted Bid Price Between SMA and Polymer-Modified Superpave Mixtures; (a) States Allowing RAP/RAS in SMA; (b) States Not Allowing RAP/RAS in SMA.

SMA with RAP

- Background
  - NCAT Test Track (Report NCAT 21-03)
    - 2012 Cycle: CCPR sections included 11% RAP in SMA surface (N4, N4 and S12)
      - Excellent crack performance and excellent rutting performance
    - 2018 Cycle: Thinlay SMA with 20% Fine Fractionated RAP
      - Performed well with no cracking
  - MoDOT Research Report Number cmr 23-016 (Buttlar et al., 2023)
    - Laboratory investigation of SMA with RAP and SMA with GTR
      - Recommendation: Allow up to 15% RAP

SMA with RAP


Amount of RAP Milled from Pavements
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Tons
D1
D2
D3
D4
D5
D6
D8
D9
D10
D11
D12
District
2019
2020
2021


3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Tons
2019
2020
2021
Year
Excess RAP
Asphalt Milled
RAP used in Asphalt (18%)

Fiberless SMA

- Item 419: Stabilizing agents allowed:
  - Cellulose Fibers
  - Cellulose Pellets
  - Mineral Fiber
  - Crumb Rubber
  - WMA Additive

https://antrocel.com

Fiberless SMA

- Fiberless SMA:
  - Uses WMA additive and lower temperatures to mitigate draindown
    - Item 419, Max Temperature = 300F
    - Conventional SMA temperature = 315 – 325F
    - Fiberless SMA temperature = 275 – 285F
  - Benefits:
    - produce SMA at any plant without specialized equipment
    - Lower temperature = lower GHG emissions/GWP

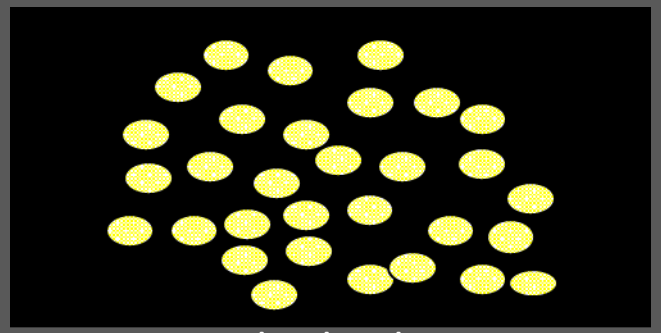
Fiberless SMA

- Fiberless SMA Pilot Project
  - Route: SR 376
  - Contractor: Lindy Paving
  - Year: 2022
  - For more details: https://www.pa-asphalt.org/images/2023/24_-_Martin_Libertini_Lindy_Dominic_Barilla_Ingevity_-_Fiberless_SMA.pdf

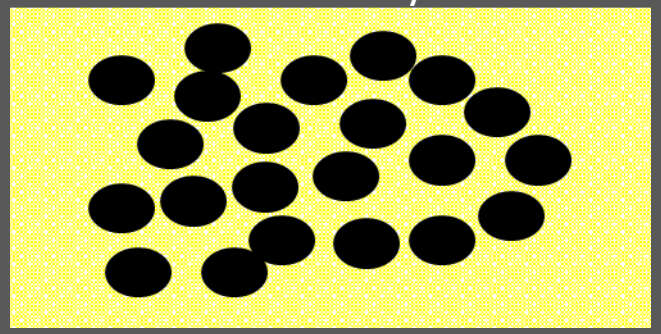
SMA with Highly Polymer Modified Asphalt

Pennsylvania Department of Transportation (PennDOT)	$700,000	PennDOT will deploy Targeted Overlay Pavement Solutions, an EDC innovation supported by FHWA, that feature Stone Matrix Asphalt and Highly Modified Asphalt in projects in five of its Engineering Districts. The pavement solutions enhance overlay performance for both asphalt and concrete pavements, reduce maintenance, maximize previous investments through extended service life of pavement structures, reduce congestion through the need for less work zones, increase skid resistance, improve resiliency in flood-prone areas, and reduce noise.

Highly Polymer Modified AC



Standard Polymer



Highly Modified = 3x Polymer

Highly polymer modified AC:

- Typical Polymer dose = 2.5%
- **<u>High polymer dose is 3x greater = 7.5%</u>**
- Improved rutting resistance and cracking resistance
- In PA, high polymer binder = PG 76E-28 (88-28) (In ^{o}F: 190.4 -18.4)

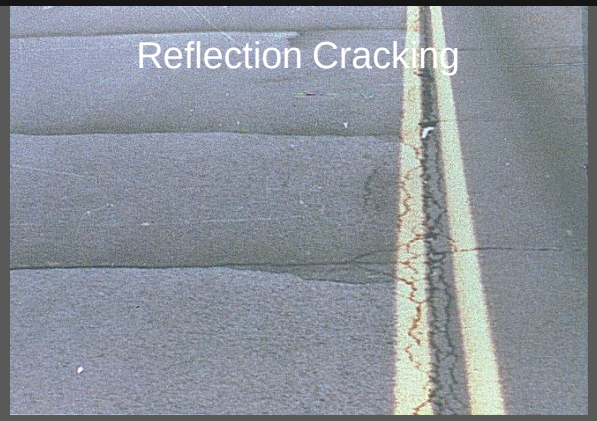
Binder Grade	Traffic	Designation
PG 64S-22	Standard	S
	Heavy	H
	Very Heavy	V
PG 64E-22 (76-22) PG 76E-28 (88-28)	Extreme	E

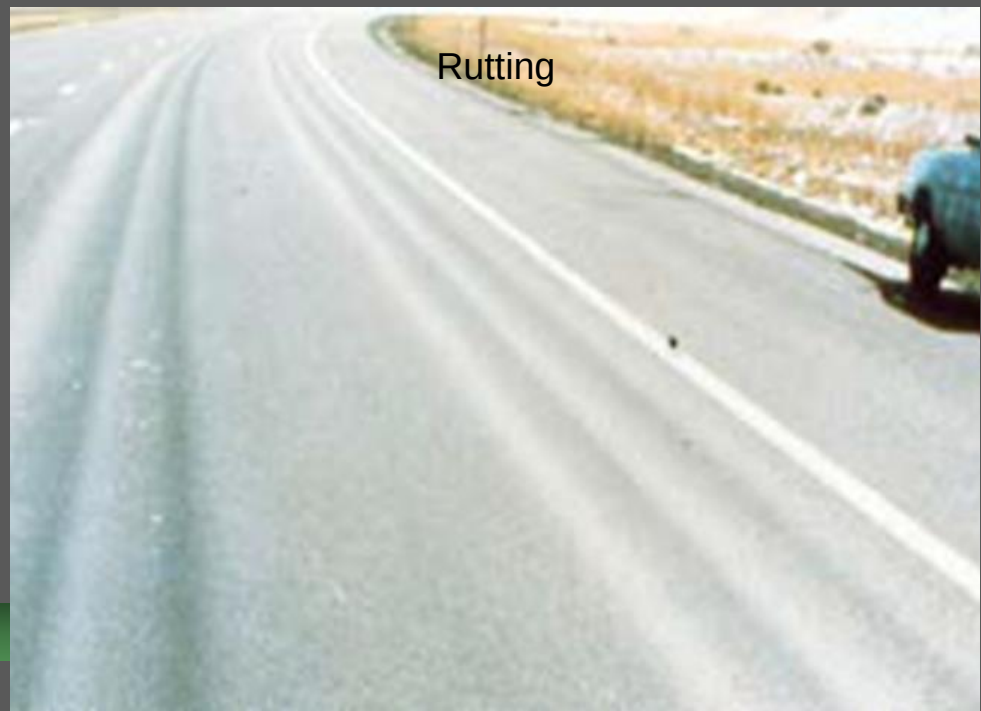
Innovations in SMA: Pub 408, Item 419

- Fiberless SMA: Permissive (Contactor's choice)
- Up to 10% RAP in SMA: Prescriptive (PennDOT's choice)
- HiMA SMA: Pilot Project (special provision only)

Balanced Mix Design

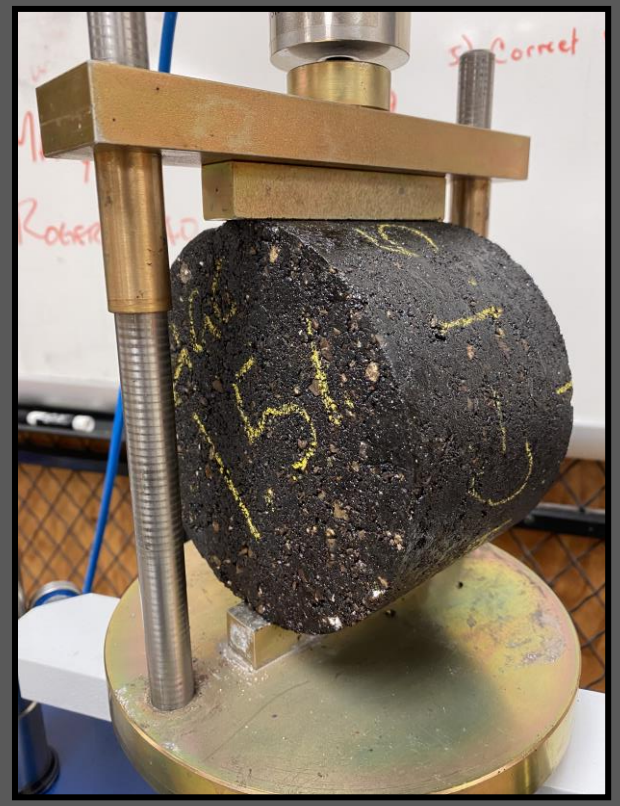
Asphalt Pavement Distresses

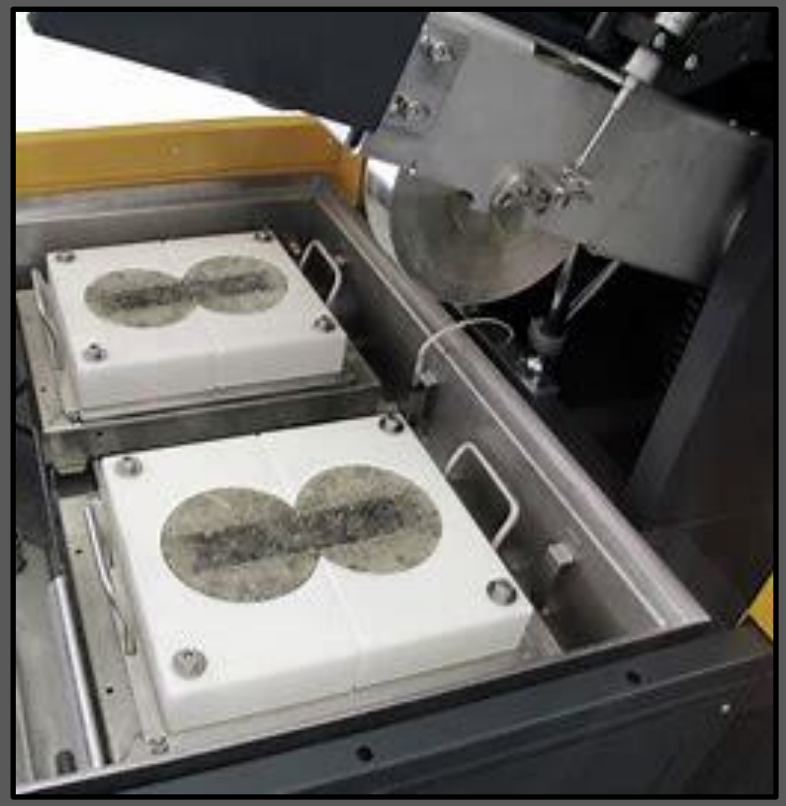




Balanced Mix Design

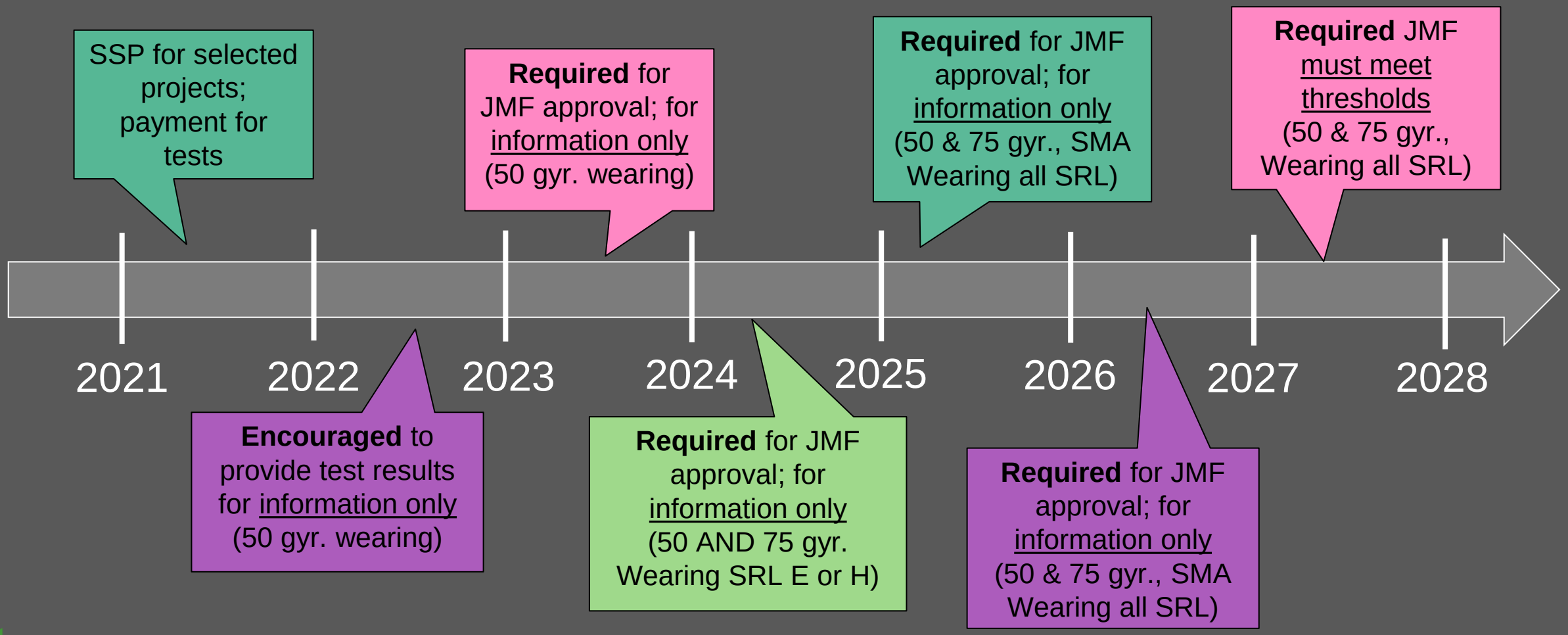
- Performance Tests:
  - Rutting
    - Hamburg Wheel Track Test (HWTT)
  - Cracking
    - IDEAL CT
  - Moisture Damage
    - Tensile Strength Ratio (TSR) and/or
    - HWTT Stripping Inflection Point (SIP)





Balanced Mix Design

SOL 481-24-01



Upcoming PAPA Events

TO REGISTER: PAPA Events (pa-asphalt.org)

PAPA ANNUAL CONFERENCE
Hotel Hershey
January 20 – 22, 2025

PAPA REGIONAL TECHNICAL MEETINGS
Pittsburgh | State College | Allentown
March 18, 20, & 20, 2025

PAPA ENVIRONMENTAL SEMINAR
Harrisburg, PA
April 16, 2025

PAPA/PENNDOT BUS TOUR
District ???
July 29 & 30, 2025

Thank you....

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