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PA Asphalt Pavement Association

# Stone Matrix Asphalt

**July 30, 2025**

*PennDOT – PAPA Bus Tour*

*District 10: Cranberry Township, PA*

# SMA

- History
- What it is
- How to use it
- Innovations
  - Fiberless SMA
  - HiMA SMA

# Stone Matrix Asphalt (SMA)

aka: Stone Mastic Asphalt



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# 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
  - Gap-graded aggregate structure
    - 70-80% coarse aggregate
    - 8 – 12% Mineral filler



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



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# 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

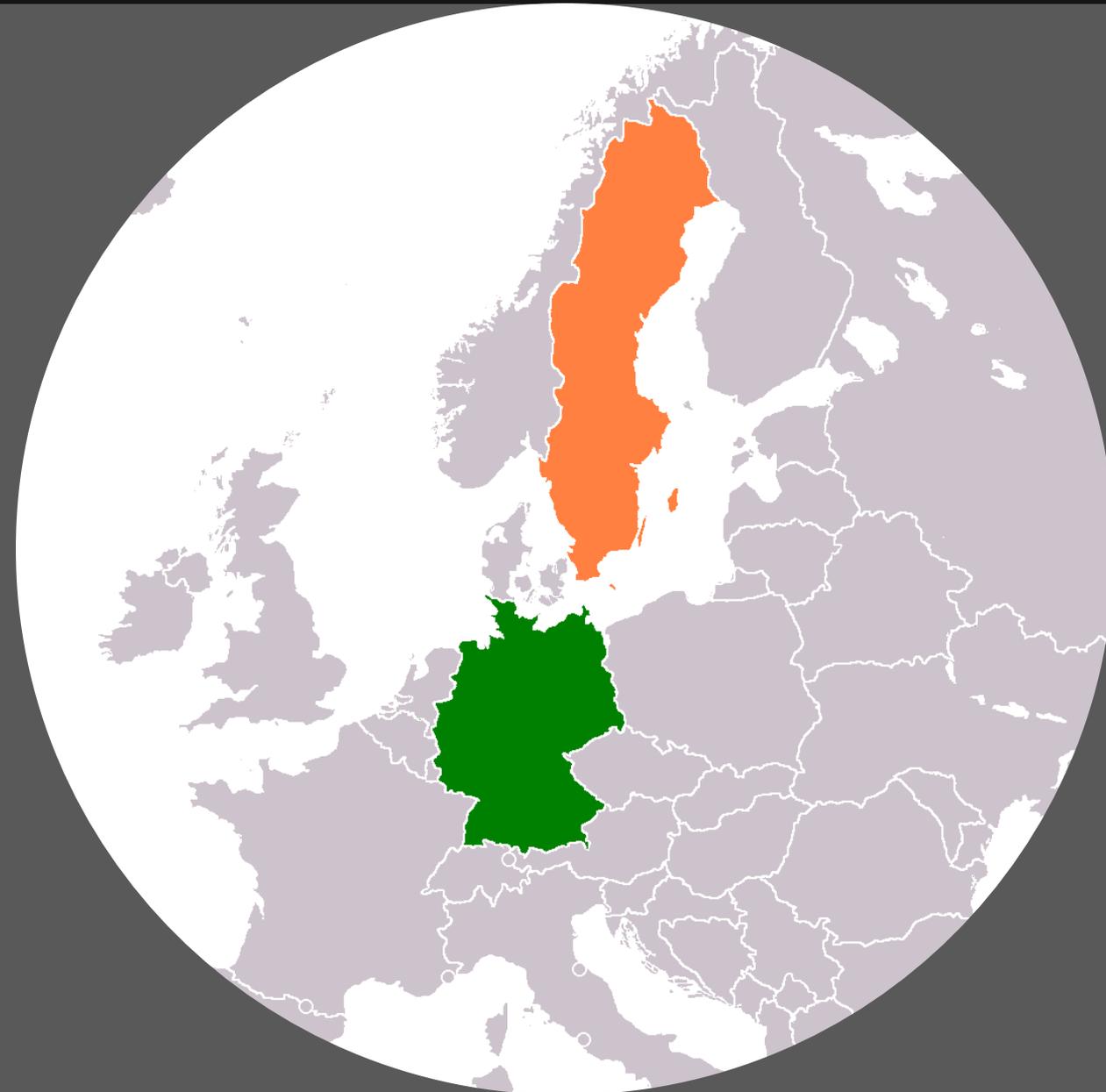


Image source: Wikipedia



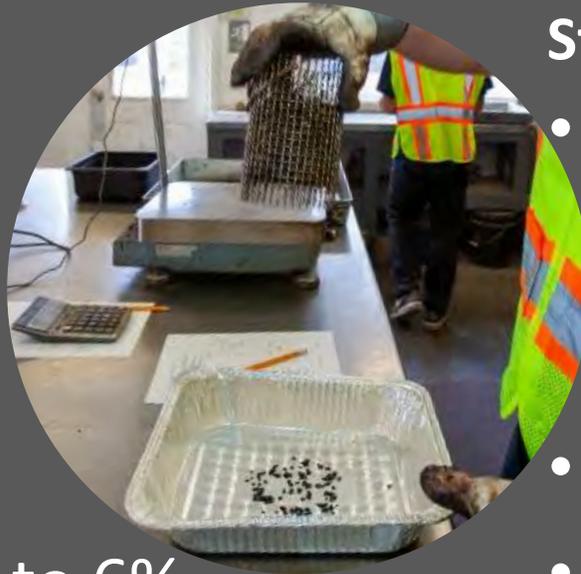
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# SMA vs Dense Graded Superpave:

## 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 Benefits

Extended Performance Life

Rut Resistance

Improved Durability

Improved friction

Reduced Noise



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# 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



# SMA Benefits

- Extended Life:  
Composite Pavements

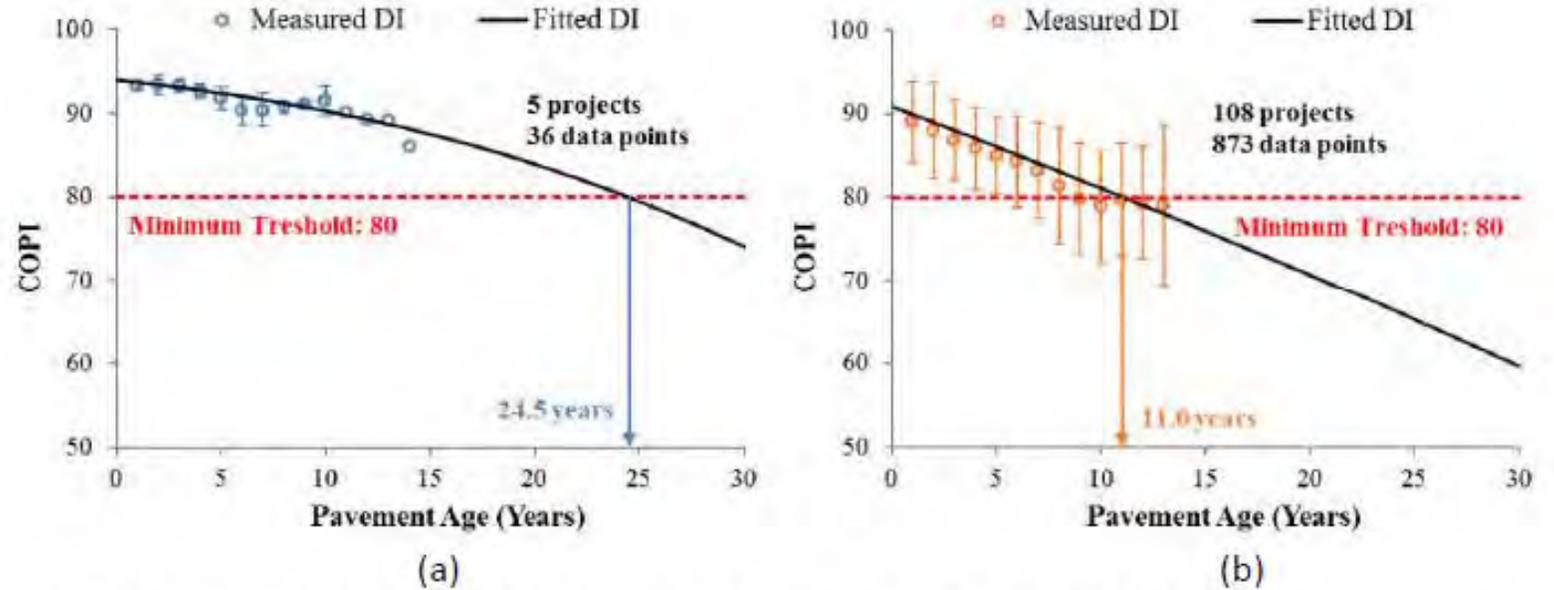


Figure 14. Pennsylvania DOT OPI Data of Composite Pavements on NHS Non-Interstate Routes; (a) SMA, (b) Polymer-Modified Superpave Mixtures

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

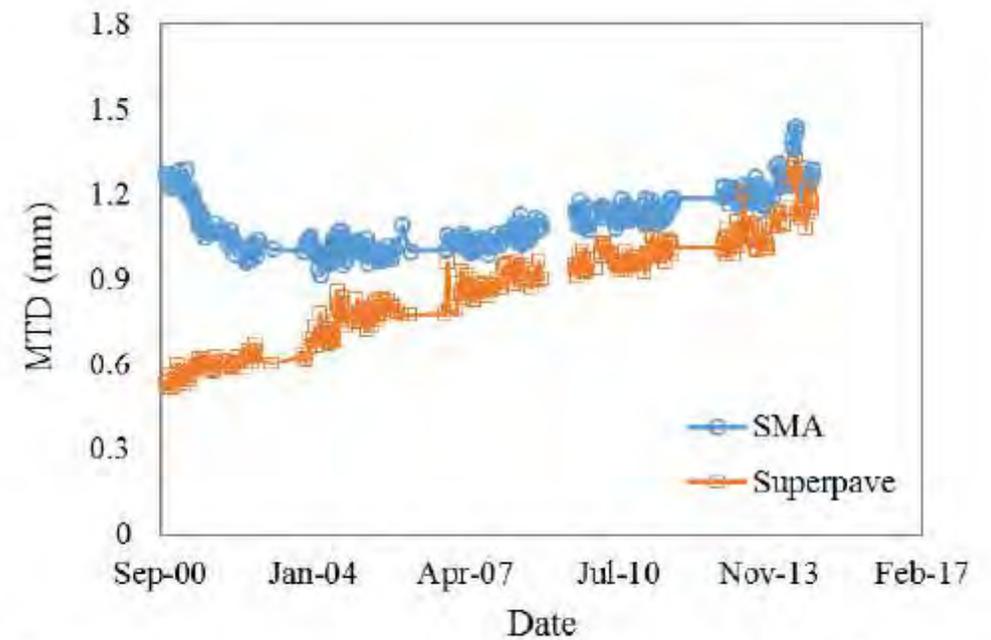
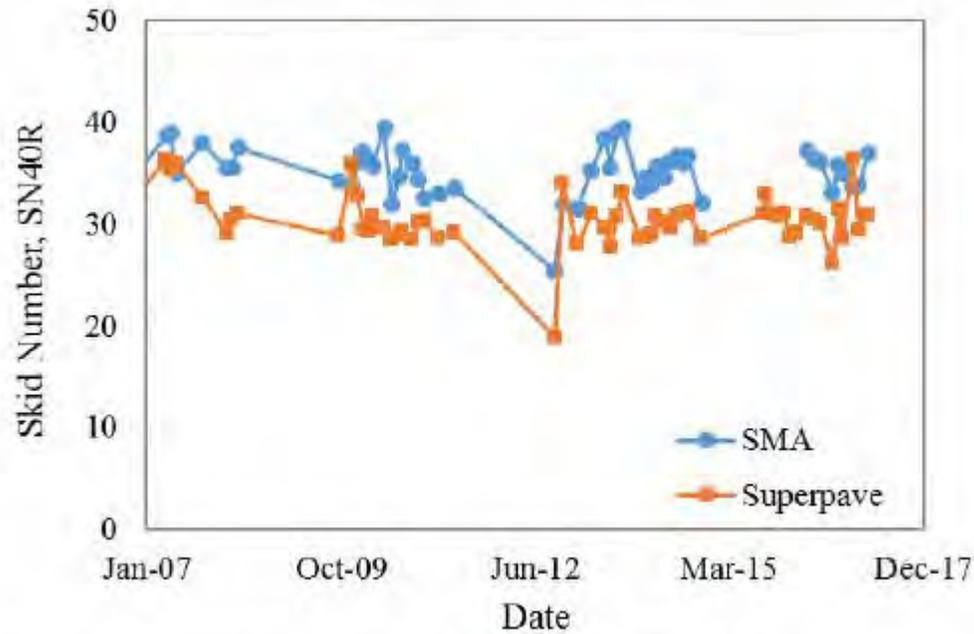


Figure 41. Surface Friction Comparison of NCAT Test Track SMA and Superpave Sections | Figure 40. Macrotexture Comparison of NCAT Test Track SMA and Superpave Sections

# 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



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# 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
- Place where structural rutting exist



# Innovations in SMA



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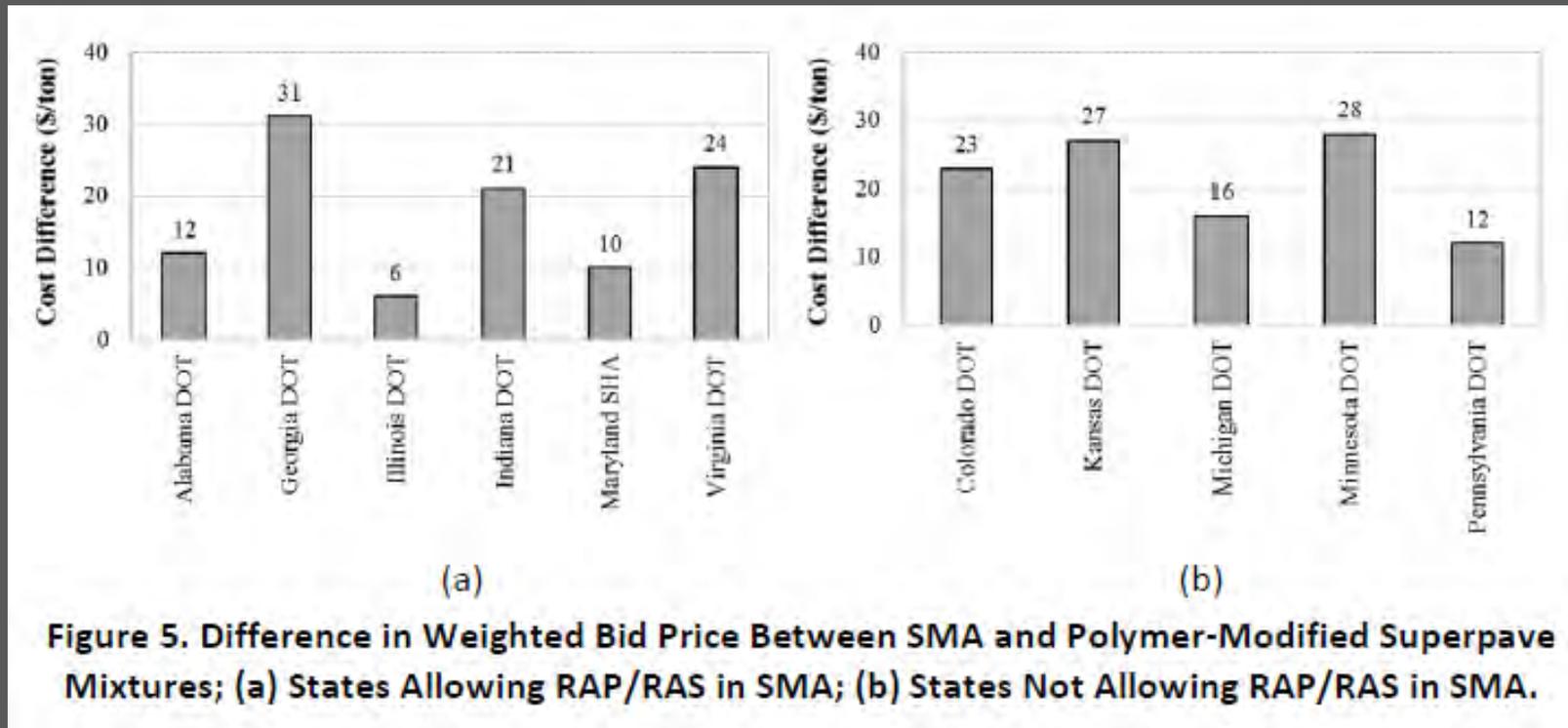
# Innovations in SMA: Pub 408, Item 419

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



# SMA with RAP

- Background
  - States allowing RAP in SMA (as of 2018):



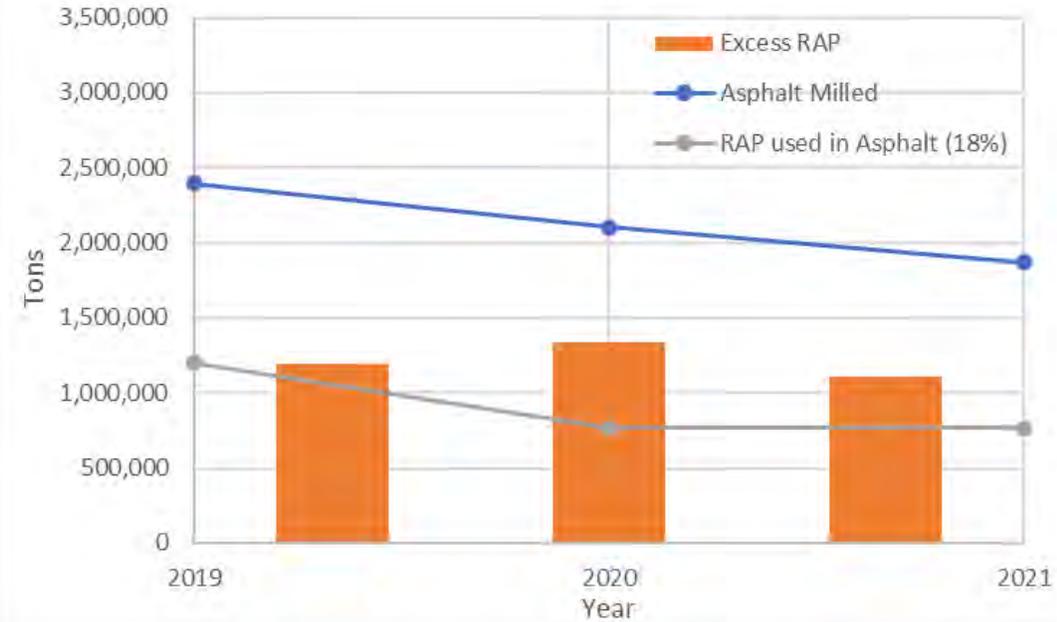
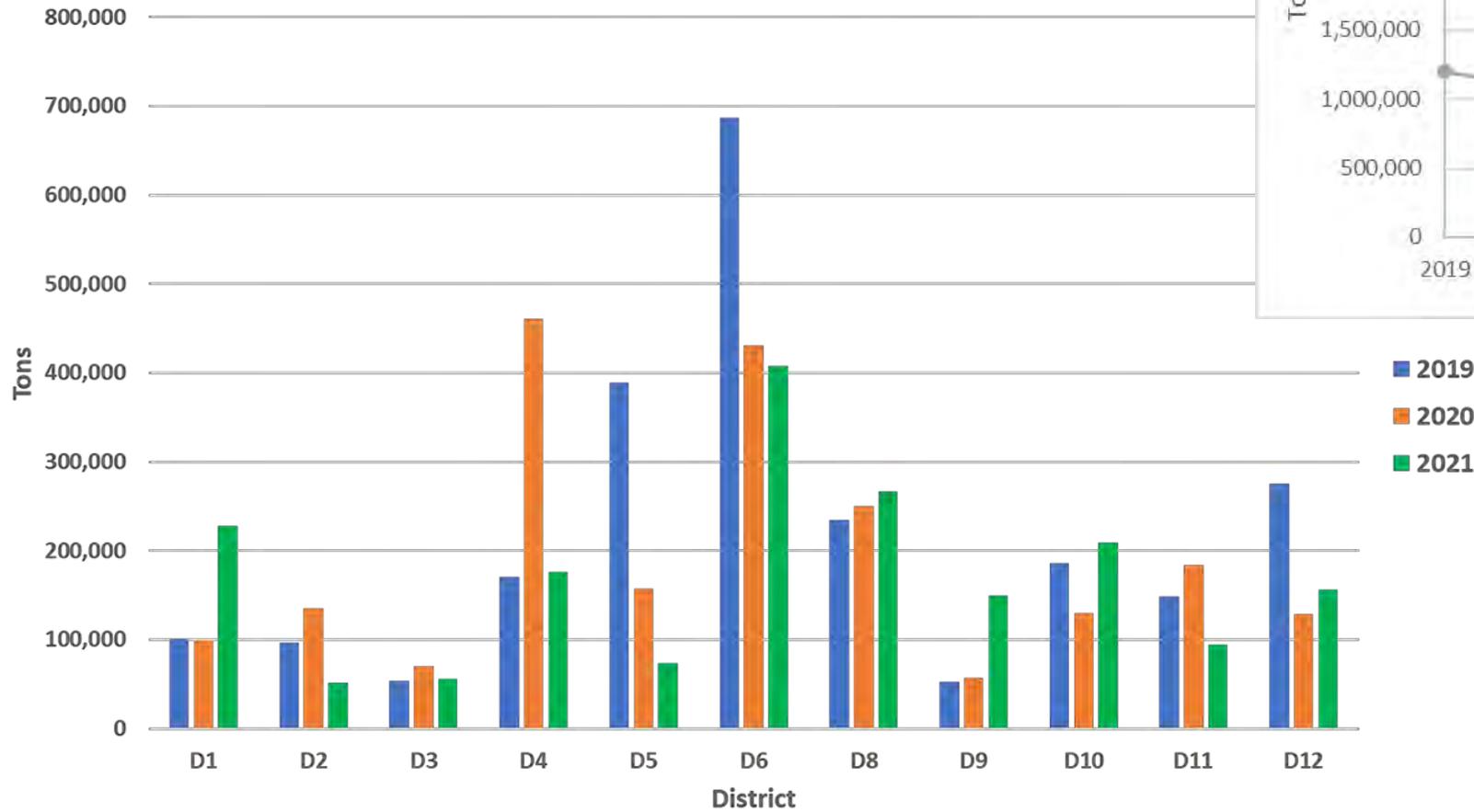
# SMA with RAP

- 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



# Fiberless SMA

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

<https://antrocel.com>



**ANTROCEL-P**

Cellulose Fiber for SMA  
Asphalt Mixtures



**ANTROCEL-G**

Cellulose Fiber Pellets for SMA  
Asphalt Mixtures

# SMA Draindown



Image source: [R. Steger](#)

- Liquid binder running off aggregate surface
- Results in fat spots and segregated areas of high and low binder content on the mat



# Fiberless SMA

- Mastic (asphalt binder + filler + fibers) improve viscosity and prevent draindown
- BUT, fibers can be challenging to design and produce with
- How would you maintain viscosity without fibers?

**You MUST drop the temperature!**

**&**

**Add a WMA additive!**

**Viscosity = Resistance to Flow**

↑ Viscosity = ↓ Flow

↑ Temperature = ↑ Flow



# Fiberless SMA

Image source: [M. Libertini, Lindy Paving Group](#)



## Temperature, temperature...TEMPERATURE!

- Conventional SMA production temperature: 315 – 325F
- Fiberless SMA production temperature: 265 – 295F
  - Item 419, Max Production/Compaction Temperature = 300F (Fiberless)



# Fiberless SMA



- Benefits:
  - produce SMA at any plant without specialized equipment
  - Lower temperature = lower GHG emissions/GWP
  - rain event does not impact ability to make mix

# Fiberless SMA

- Transport:
  - Reduces mix buildup in truck beds
- Placement
  - Temperature at the paver 245 – 265F
  - No change with hand work
- Compaction
  - No change
  - May experience more movement under rollers than traditional SMA, does not impact density
  - Eliminates fat spots



# 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](https://www.pa-asphalt.org/images/2023/24_Martin_Libertini_Lindy_Dominic_Barilla_Ingevity_-_Fiberless_SMA.pdf)



# Dos and Don'ts of Fiberless SMA

## Do

- Control mineral filler
  - Silo interlocked with plant controls, preferred
  - RAP bin

## Don't

- Allow mineral filler to fluctuate too much
  - Introduce mineral filler in a cold feed bin



Image Source: <https://www.admasphaltplants.com/filler-dust-silo-equipment/>

# Dos and Don'ts of Fiberless SMA

## Do

- Understand your draindown-temperature relationship
- Calibrate WMA additive pump, if metered at plant

## Don't

- Exceed 305F, even at start-up
- Ignore WMA additive



# SMA with Highly Polymer Modified Asphalt

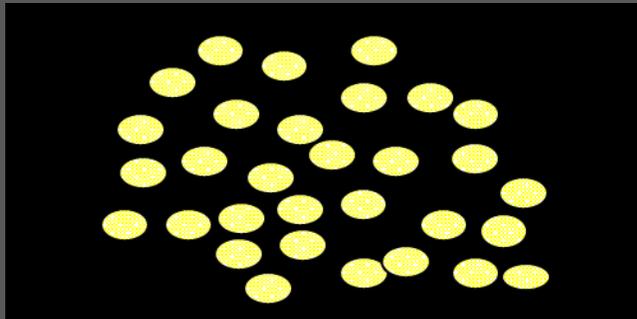
<p>Pennsylvania Department of Transportation (PennDOT)</p>	<p>\$700,000</p>	<p>PennDOT will deploy Targeted Overlay Pavement Solutions, an EDC innovation supported by FHWA, that feature Stone Matrix Asphalt and Highly Modified Asphalt in projects in five of its Engineering Districts. The pavement solutions 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.</p>
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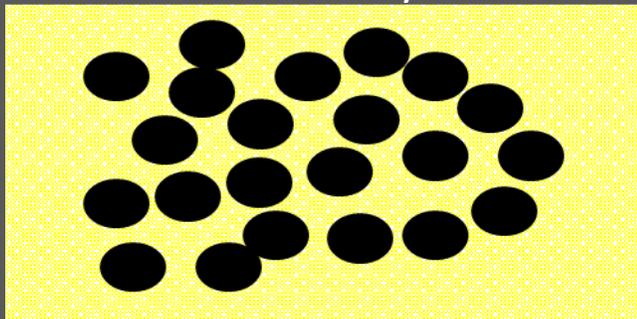
# Highly Polymer Modified AC

Highly polymer modified AC:

- Typical Polymer dose ~ 2.5%
- Higher polymer dose for elastic recovery
- Improved rutting resistance and cracking resistance
- In PA, high polymer binder = PG 76E-28 (88-28) (In °F: 190.4 -18.4)



Standard Polymer



Highly Modified = 3x Polymer

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

# HiMA FAQs

- Can I add a WMA additive to it?
  - Yes
- Can I foam with HiMA
  - No
- What kind of temperature do I need to produce at?
  - Don't overheat the HiMA binder; at  $T > 340\text{F}$ , the binder increases in viscosity and will decrease mix workability
    - Tank temperature: 300 – 340 F
    - Mix production temperature: 310 – 340 F



# HiMA FAQs

- How do I store HiMA binder?
  - Continuous agitation not necessary but period agitation or recirculation recommended
  - Mix tank before starting production or sampling
  - Consult with the asphalt supplier on timeframes, and transition storage tank from one binder to another
  - Long-term storage is NOT recommended



# HiMA FAQs

- Does it act differently in the field?
  - It has extra polymer so it will be stickier!
  - Be mindful of hauling & delivery and lay-down practices
- How to handle hauling & delivery
  - Load into clean and empty trailers
  - Warm trailers preferred
- How to handle lay-down?
  - Follow best practices (always)! HiMA will magnify poor practices
  - Balance delivery and paver speed
  - Temperature is important!



# Thank you....

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Please tell us how we did:



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