Image source: NAPA

Image source: ACPA

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TOPS

Targeted Overlay Pavement Solutions

A solution for extending the life of an existing pavement investment.

Tim Aschenbrener, P.E.
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Pavement Materials Team
FHWA: Office of Infrastructure

Every Day Counts
Innovation for a Nation on the Move

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Acronyms and Abbreviations

- AASHTO = American Association of Highway and Transportation Officials
- AC = Asphalt content
- ARGG = Asphalt rubber gap graded
- CAM = Crack attenuating mixture
- CP2 = California Pavement Preservation Center
- EDC = Every Day Counts
- GTR = ground tire rubber
- HiMA = Highly modified asphalt
- HPTO = High performance thin overlays
- HWTT = Hamburg wheel track test
- MTV = Material transfer vehicle
- NCAT = National Center for Asphalt Technology
- NMAS = Nominal maximum aggregate size
- OGFC = open-graded friction course
- PCC = Portland cement concrete
- PG = Performance grade
- QPL = Qualified producer list
- RTR = Recycled tire rubber
- SBS = Styrene butadiene styrene
- SMA = Stone matrix asphalt
- TOM-C = Thin overlay mixture - coarse
- TOM-F = Thin overlay mixture - fine
- TSR = Tensile strength ratio
- UTBWC = Ultra thin bonded wearing course
- VCA = Voids in the coarse aggregate
- VMA = voids in the mineral aggregate

Presentation Outline

- EDC-6 Targeted Overlay Pavement Solutions (TOPS)
- Highly Modified Asphalt (HiMA)
- Ultra-thin Bonded Wearing Course (UTBWC)
- Crack Attenuating Mixture (CAM)
- Stone Matrix Asphalt (SMA)
- Open Graded Friction Course (OGFC)
- Asphalt Rubber Gap Graded (ARGG)

FHWA TOPS EDC-6 Team

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Background

- Over 25% of all State DOT infrastructure funds go to pavements overlays.
- State DOT manage 2.8 million miles of pavements.

- *Information source: FHWA (https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/targeted_overlay_pavement.cfm)*

Image source: Iowa State University

How is this different from typical overlays?

TOPS matches treatments to high-priority, high-need locations.

Image Source: Georgia DOT

EDC-6 Goals

- Increase the number of participating agencies that demonstrate, assess, or institutionalize an additional TOPS technology not previously institutionalized.
- Build awareness and expand TOPS usage.
  - Identify a champion at each State agency.
  - Share information at conferences/workshops.
  - Train people (webinars/peer exchanges).

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Highly Modified Asphalt (HiMA)

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HiMA Characteristics

- Asphalt binder modified with 7 – 8% Styrene Butadiene Styrene (SBS) polymer.
- Conventional polymer modified binders contain 2 – 3% polymer.
- Polymers for HiMA binders have a slightly different chemical structure than conventional polymers.

SBS Polymer Pellets

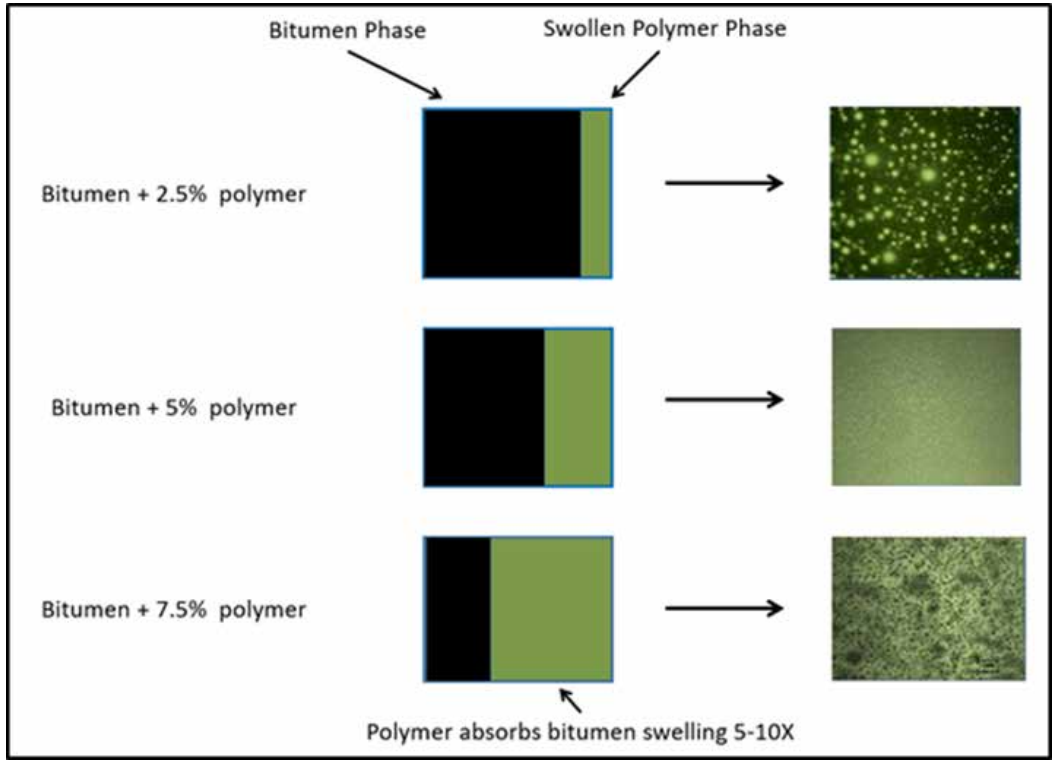
Source: NCAT

HiMA Characteristics

Effect of increasing SBS polymer content on binder/polymer morphology.

- Conventionally-modified binders consist of an asphalt binder structure with a dispersed swollen polymer phase.
- HiMA binders consist of a swollen polymer structure with a dispersed asphalt phase.
- HiMA binders behave more like rubber and enhances cracking resistance and rutting performance.

Polymer Bitumen Interaction

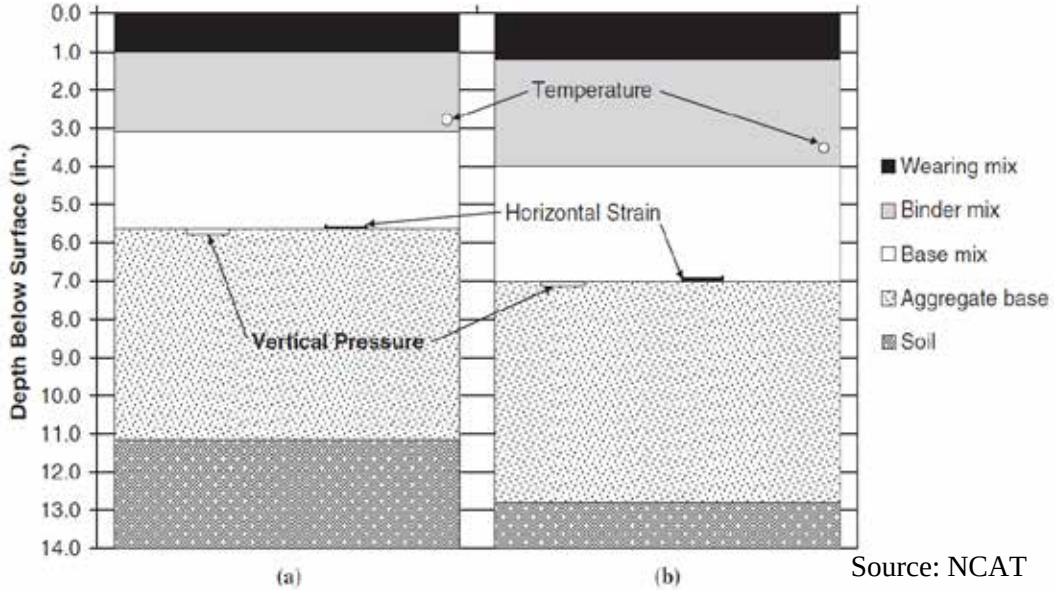


Potential Benefits of HiMA

- Improved rutting resistance.
- Improved fatigue cracking resistance.
- Improved raveling resistance.
- Potential thickness reduction.

After 20 million equivalent single-axle loads of trafficking, the HiMA test section had performed as well or better than the control section despite being constructed 1.25 inches thinner.*

NCAT Test Track Trial Sections



Source: NCAT

*Willis, R., Timm, D. and Klutz, R. (2016). Performance of a High Polymer-Modified Asphalt Binder Test Section at the National Center for Asphalt Technology Pavement Test Track. Transportation Research Record, No. 2575: 1-9. https://doi.org/10.3141/2575-01.

HiMA Applications

- Project selection criteria.
  - “Premium” mixture – more costly.
  - Typically selected to target specific distresses.
- High Stress Applications.
  - Intersections; weigh stations; high volume facilities.
- Structural Applications.
  - Potential reduced pavement thickness.
  - Offset weaker base/subgrade.
- Other TOPS products:
  - Thin Overlays.
  - Open-Graded Friction Course (OGFC).
  - Crack Attenuating Mixtures (CAM) Inter-layer.
  - Stone Matrix Asphalt (SMA).

Fatigue Cracking

Source: Florida DOT

High Volume Intersection

Source: Florida DOT

Materials and Mixture Properties

Binder Specifications (AASHTO M 320)

Agency	Performance Grade	Properties
Minnesota	PG 76-34	ER ≥ 90%
New Hampshire	PG 76-34	ER ≥ 90%
Ohio	PG 88-22	ER ≥ 90%
Oregon	PG 76-28	ER ≥ 90%
New York City	PG 76-34	ER ≥ 90%
Utah	PG 76-34	ER ≥ 90%
Vermont	PG 76-34	ER ≥ 90%
Washington	PG 76-34	ER ≥ 90%

Use of the AASHTO M 320 specification is not a Federal requirement.

Production and Construction Practices

- When starting, suppliers may be limited.
  - Monitor projects during design.
  - Talk with HiMA binder suppliers.
- HiMA binder is more difficult to produce.
  - Good communication to assure timely supply.
- Finite storage period.
  - Allowances provided to minimize storage issue.
    - Blend down procedure.
    - Usage in non-HiMA applications with RAP.

Binder Storage Tanks

Source: CRH Americas Materials

Florida DOT HiMA Projects

- HiMA is the premier binder - replaced PG 82-22.
- Completed 50+ projects with HiMA.
- Placed over 600,000 tons of HiMA mix.
- Usage is growing – but where needed.
- 8 asphalt terminals on QPL.

Image Source: Florida DOT

Image Source: Florida DOT

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Ultra-Thin Bonded Wearing Coarse (UTBWC)

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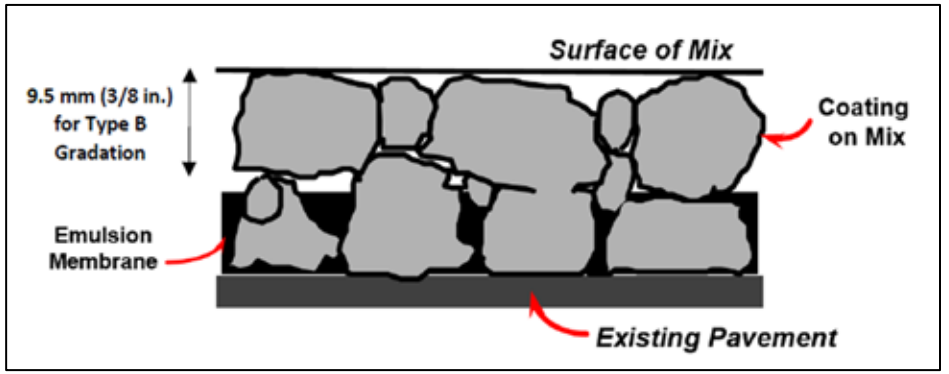
UTBWC Characteristics

- Heavy, polymer-modified asphalt emulsion membrane.
- Placed using a spray paver in a single pass.
- Placed in 0.4-inch to 0.8-inch lift.
- Gap-graded polymer-modified No. 4 to ½ inch NMAS asphalt mixture.

Newly Paved Ultra-Thin Bonded Wearing Coarse (UTBWC) Section Source: MnDOT 2022



UTBWC Schematic Source: MnDOT 2018

UTBWC Terminology

- Minnesota DOT (MnDOT)
  - Ultra-thin bonded wearing course (UTBWC)
- Pennsylvania DOT (PennDOT)
  - Mixture: Ultra-thin wearing course (UTWC)
  - Emulsion: Ultra-thin wearing course emulsion membrane (UTWCEM).
- California DOT (Caltrans)
  - Bonded wearing course (BWC)

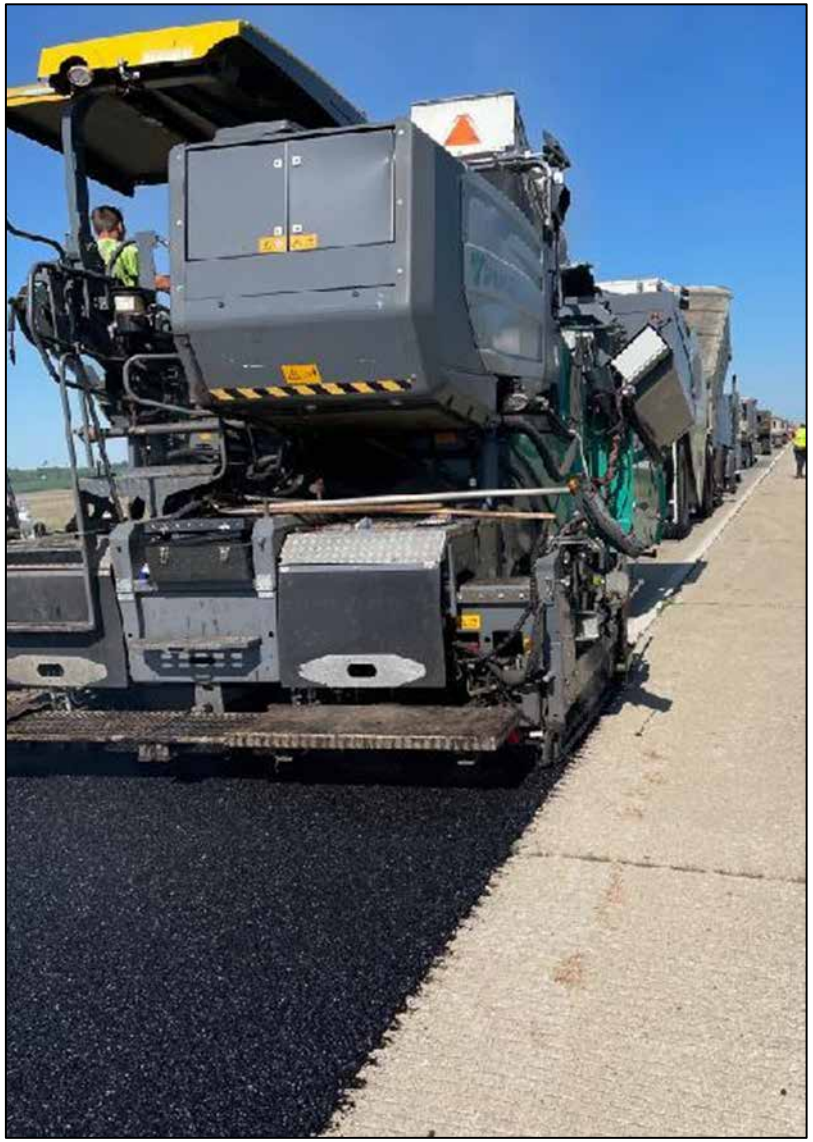
Placement of UTBWC

Source: MnDOT

UTBWC Background

- Proprietary system originally developed in France in 1986.
- Successfully used in Europe as preventive maintenance and surface rehabilitation technique.
  - Restoring skid resistance.
  - Sealing the surface.
- First sections of UTBWC in the U.S. were placed by Mississippi, Alabama, and Texas DOTs in the early 1990s.
- Over the years, optimized materials and construction processes.

Placement of UTBWC



Source: Asphalt Surface Technologies Corp

UTBWC Applications

- Pavement preservation to extend pavement life.
- The underlying pavement must be structurally sound and in “good” condition with only minor distresses.
- Adds service life to the pavement without a significant change in profile grade.
- High traffic volumes / Interstates.

Source: MNDOT

Production and Construction Practices

Spray Paver.

- Combines tack distributer and paver.
- Bonding agent and HMA placed in one pass.
- Improved bonding since there are no opportunities to track dirt and debris onto tack/bonding or pickup tack/bonding on construction equipment.

Material Transfer Vehicle (MTV) and Spray Paver

Source: Asphalt Surface Technologies Corp.

Source: Arrmaz (2016)

Minnesota DOT UTBWC Projects

- One of the most expensive applications per square yard compared to other non-HMA treatments.
- Performance is expected from 7 to 12 years, an average of one-third more life than other treatments.
- Average gain in pavement life using UTBWC exceeds the additional cost needed to apply other similar treatments.

Source: Asphalt Surface Technologies Corporation

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Crack Attenuating Mixture (CAM)

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CAM Characteristics

- Interlayer paired with surface mix.
- Aggregate components:
  - Fine gradation.
  - NMAS of No. 4 to 3/8 inches.
  - High-quality aggregates
- Binder components:
  - High asphalt content (typically around 7.0%).
  - Polymer-modified asphalt.
- Mixture performance testing for crack and rut resistance.

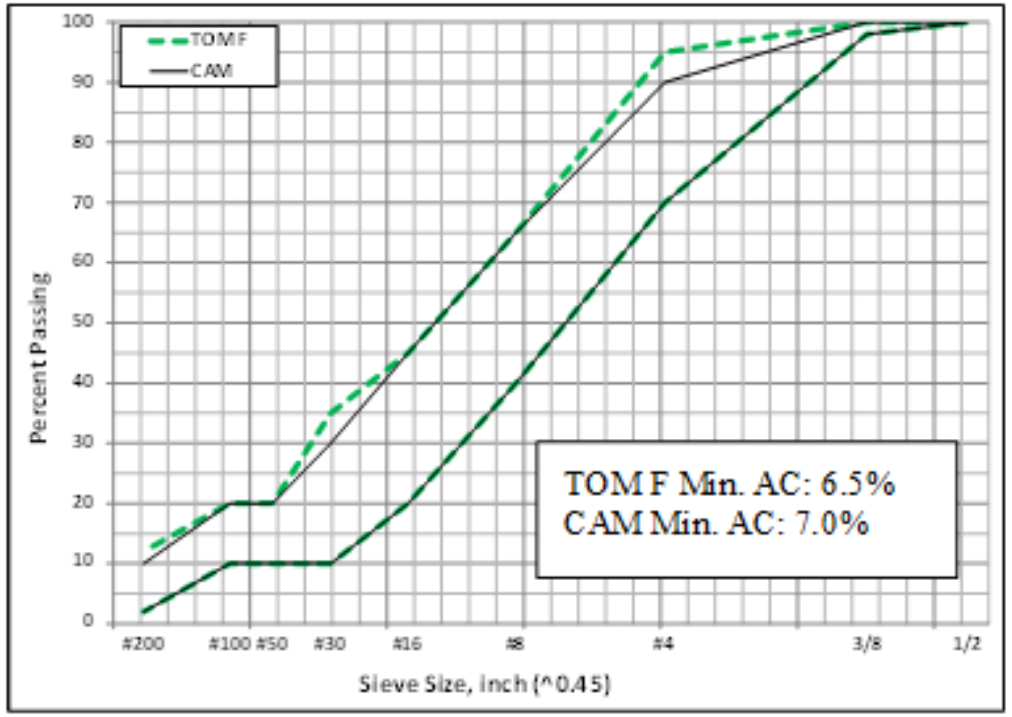
CAM Terminology

- Binder/bituminous-rich intermediate course (BRIC).
  - New Jersey DOT.
- Engineered stress relief course (ESRC).
  - Nevada DOT.
- Stress Absorbing Membrane Interlayer (SAMI).
- Crack relief interlayer.
- Stress relief course.
- Fracture-tolerant shear-resistant interlayer.

CAM Background

- Inspired by a proprietary crack relief interlayer marketed in the 1990s.
- The proprietary product was crack resistant but not rut resistant.
- TxDOT desired product that used local materials and was crack and rut resistant.
- TOM-F Background
  - Developed to find a use for a surplus of high-quality fine aggregate piles leftover from coarse aggregate production.

Broadband gradations for CAM and TOM-F



Source: FHWA 2021

Potential Benefits of CAM

Properly designed CAM interlayers can reduce the number of reflective cracks and slow the rate of reflective cracking.

Lab samples of CAM interlayer and TOM-C surface course.

Source: Tom Scullion, TTI, 2014

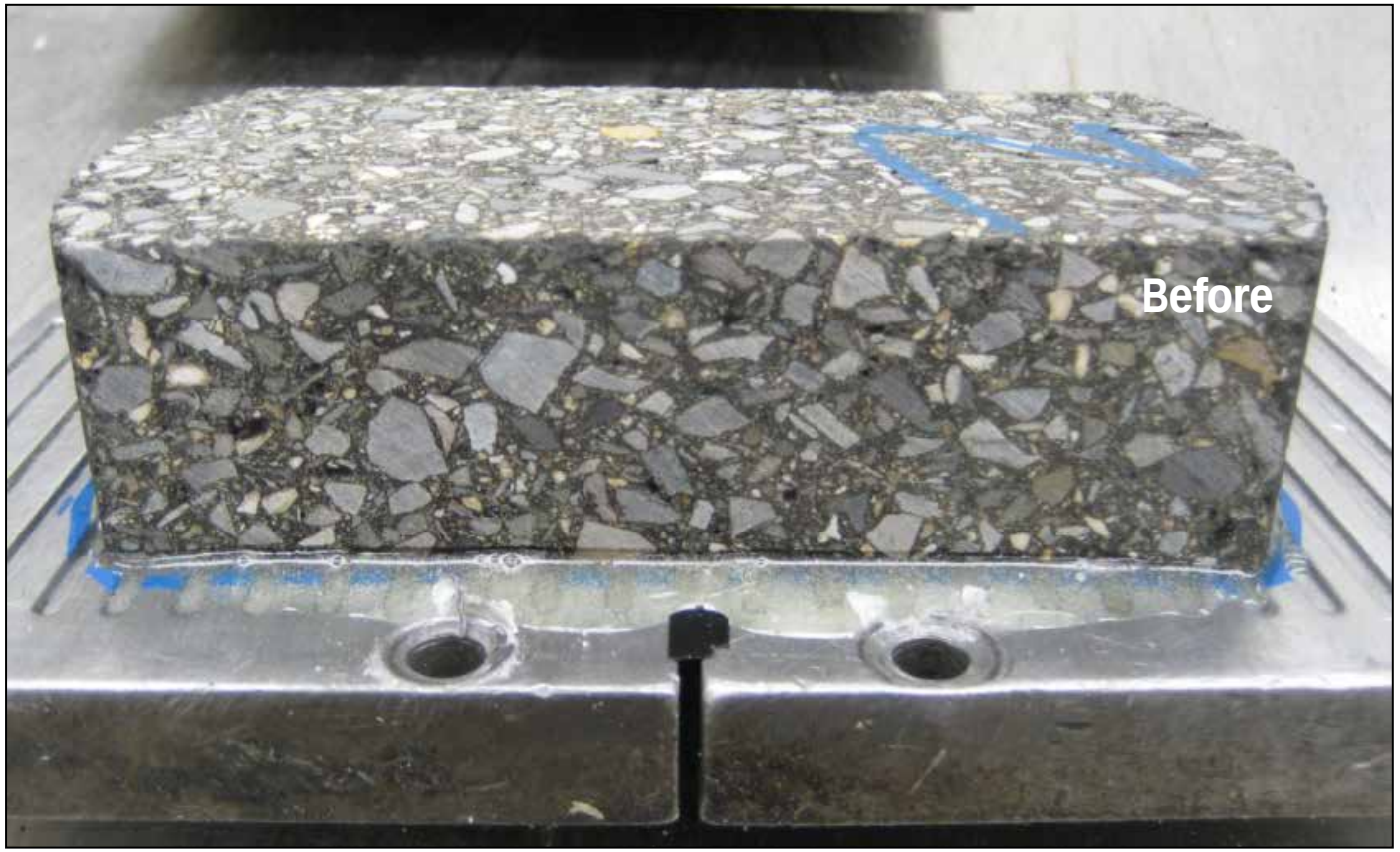
CAM Applications

- Interlayer for reflective crack mitigation.
  - Concrete.
  - Asphalt.
- TxDOT rule of thumb(TxDOT 2021):
  - Surface cracks not wider than 3/8 inch.
  - Rutting less than 1/2 inch.
- Surface mixture selection important.
  - Some crack attenuating properties in the surface mix to mitigate crack jumping.

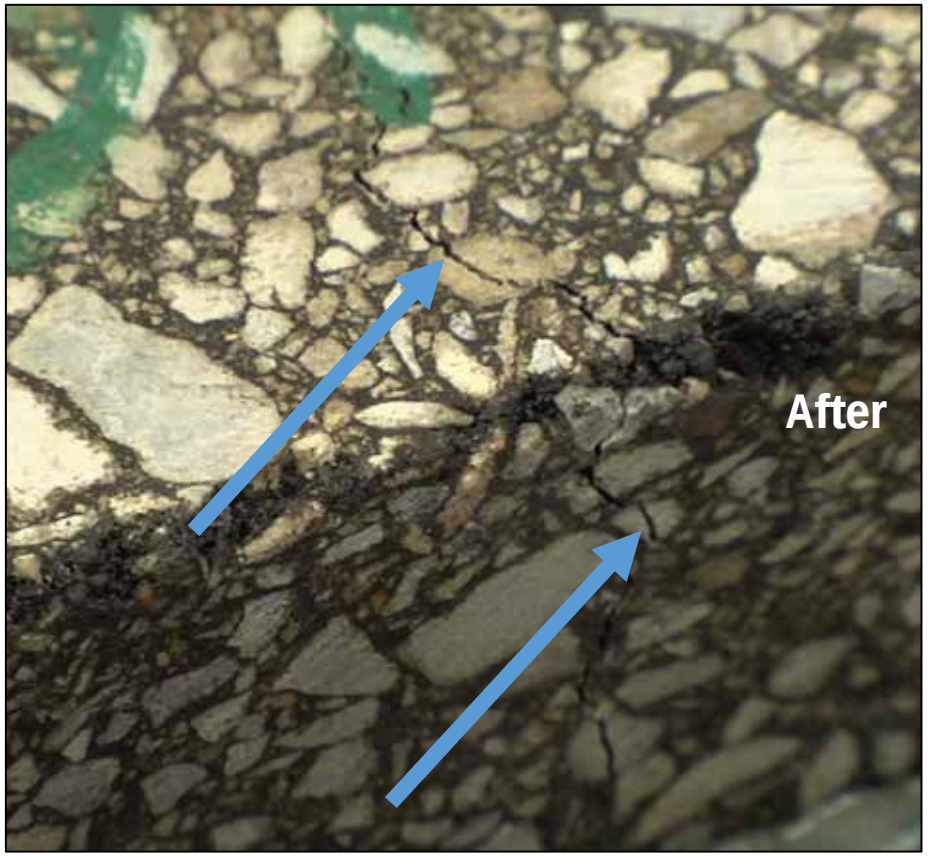
Crack jumping observed in core sample

Source: Bennert, 2018

Performance Testing – Crack Resistance
Overlay Test Tex-248-F



Source: Tom Scullion, TTI, 2014



Source: TTI 2015

Performance Testing – Rut Resistance
Hamburg Wheel Tracking Test: Tex-242-F

HWTT test equipment

Source: NCAT, 2021

HWTT test specimens after testing

Source: Tom Scullion, TTI, 2014

Production and Construction

- Repair of existing significant or structural distresses.
- Dry surface.
- Mechanism to encourage bonding and sealing (as needed) between lifts.
- Deliver >300°F with ambient >70°F.
  - Cools quickly.

Source: TxDOT (2021)

Texas DOT CAM Projects

- TxDOT has been using CAM since the early 2000s.
- Concept for CAM interlayers was initially developed as a reflective cracking mitigation.
- Overlaid with TOM-C or SMA.
- Properly designed crack attenuating interlayers can reduce the number of reflective cracks and **slow down the rate of reflective cracking up to 50 percent**.
- Cost effective!!

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Stone Matrix Asphalt (SMA)

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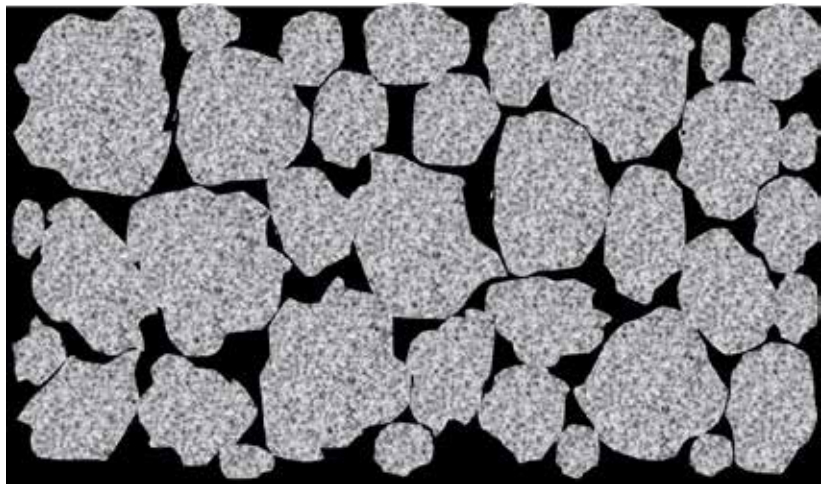
SMA Characteristics

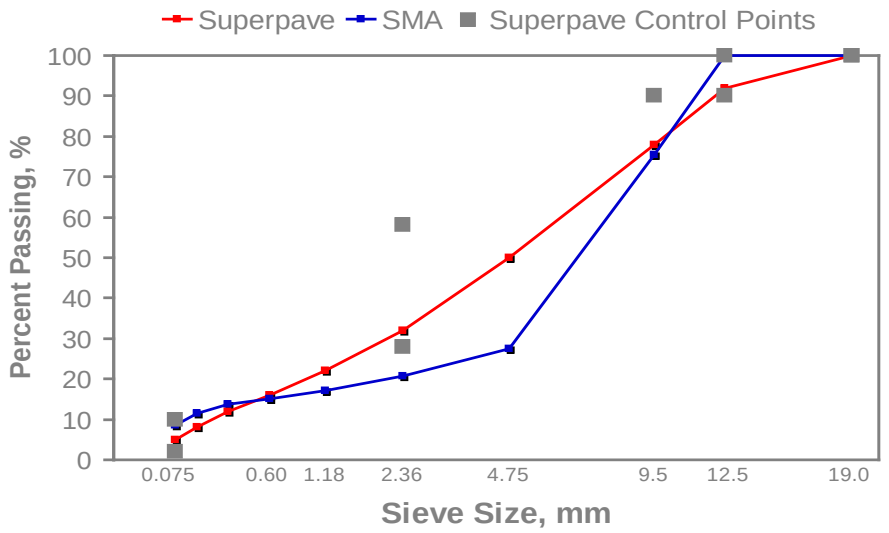
- What is SMA?
  - Gap-graded asphalt mixture.
- High quality aggregate.
  - L.A. abrasion- 30% loss maximum.
  - Design for stone-on-stone contact.
  - Fine aggregate angularity- 45% minimum.
- Rich binder mortar.
  - High asphalt content.
    - Approximately 25% thicker asphalt film than conventional mix.
  - Modified binder.
  - Mineral filler.
  - Stabilizing additives.

AASHTO M 325
AASHTO R 46

Stone-on-Stone Contact

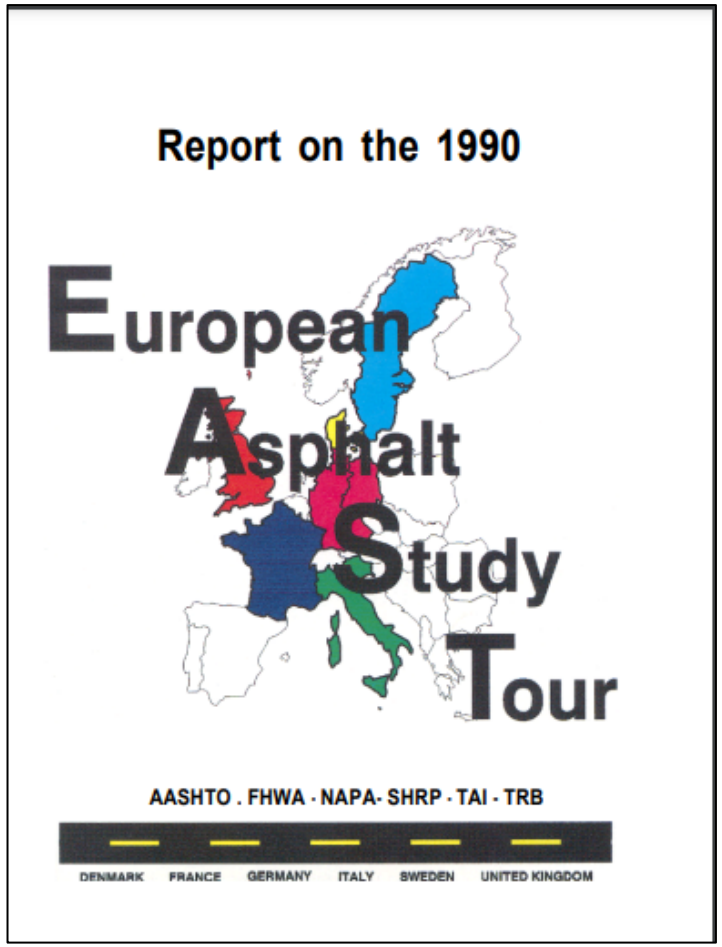
Source: NCAT





SMA Background

- Developed in Germany in 1960s.
- Introduced to U.S. in 1990.
  - Partnership of industry, government, and research.
  - Placed in heavy traffic areas.
- Current U.S. usage.
  - 18 State DOTs routinely.
  - 40 State DOTs using.



Potential Benefits of SMA

- Extended pavement life.
  - Longer service life.
  - Lower life cycle cost.
- Maximizes rutting resistance and durability.
  - Stone-on-stone contact.
  - High asphalt binder mortar.
- Retards reflective cracking on concrete pavement overlays.
- Noise reduction.
- Improved visibility on wet pavements.

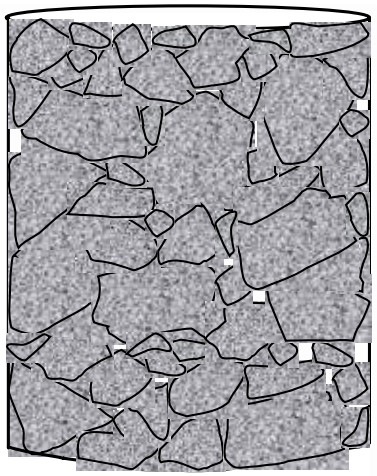
Conventional Asphalt Mix vs. SMA

Source: NCAT

Materials and Mixture Properties

- Mix design.
  - Gradation.
  - VCA (AASHTO T 19).
  - Compaction.
    - Method varies by agency.
  - VMA – 17.0% minimum.
  - Design air voids - 3.0 to 4.0%.
  - Minimum AC.
  - Draindown.
  - Moisture susceptibility.

AASHTO T 19



Source: Bill Pine

Draindown Testing

Source: NCAT

Production and Construction

- Temperature is key.
- Production.
  - Minimize start-ups and shut-downs.
  - Split primary coarse aggregate into two feeders.
  - Modify silo for feeding mineral filler.
  - Provide fiber dispersing machine.
- Placement.
  - Minimize hand work.
  - Keep operation moving with sufficient trucks.
- Compaction.
  - Pneumatic rollers not recommended.
  - Target 5% air voids.
    - 95% theoretical maximum density.

Mineral Filler Silo

Source: NCAT

Keep Operation Moving

Source: Georgia DOT

More than 4.4 million tons of SMA mix have been placed in Georgia since 1991

- Georgia uses 12.5-mm SMA beneath OGFC on all asphalt interstates.
- 19-mm SMA has been used as the intermediate layer on several GDOT projects with excellent performance!
  - This mix has been placed typically when overlaying PCC pavements.
- Projects 27 years old and counting…

Slide Courtesy of Georgia DOT

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Open-Graded Friction Course (OGFC)

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OGFC Characteristics

- Open-graded asphalt mixture with a high percentage of coarse aggregates almost uniform in size.
- Aggregate skeleton produces high air voids and coarse texture – improving friction and allowing water to drain
- Can be used as a surface lift or as part of an entire porous pavement system.

OGFC Terminology

- PEM: Permeable European Mix.
- Porous asphalt.
- Plant mix seal coat.
- Popcorn mix.
- OGSC: Open-graded surface course.
- PFC: Permeable/porous friction course.

Newly paved OGFC

Source: SCDOT 2022

- Note: Some DOTs differentiate between these mixtures (e.g., Georgia DOT uses both OGFC and PEM). The mixtures and specifications are similar but not the same.

OGFC Background

- Used in the United States and worldwide for decades.
- Some DOTs have stopped using them due to durability or maintenance issues.
- Many agencies are improving mixtures and specifications to increase durability while still achieving the safety benefits.

Reduction of splash and spray (right) compared to dense graded surface (left)

Source: National Center for Asphalt Technology

OGFC Applications

- Project selection criteria:
  - High traffic.
  - High speeds.
    - Many agencies use on all interstates.
  - Areas with evidence of wet-weather crashes.
- Repair existing structural distresses before placing OGFC.

Placing OGFC

Source: SCDOT 2022

Maintenance

- Over time, OGFC can become “clogged.”
  - Few agencies report maintenance to unclog.
  - Still may have improved permeability compared to dense graded mixtures.
- Winter maintenance techniques may vary compared to dense graded mixtures.
  - Avoid use of sand.
  - Rates of de-icing or salting may be higher than dense-graded mixes.
    - (25-50% higher, but traffic plays a role).
    - Pre-wetted salt (compared to brine or dry) can be effective.
    - Anti-icing is effective (sensitive to timing since it is placed before storms).
  - Careful snowplowing techniques.
  - Training for maintenance personnel.

South Carolina DOT OGFC Projects

- South Carolina receives nearly 50 inches of rain annually.
- SCDOT has used OGFC for years to help reduce hydroplaning on high-volume routes.
- When SCDOT realized it was getting about half the life expectancy out of its OGFC projects, the agency worked with Clemson University to identify ways to improve OGFC.
  - Determining the optimum binder content.
  - Select aggregate gradation for the necessary thickness.
  - Identify best practices for construction.
  - Identify potential maintenance solutions.

9.5 mm OGFC

Source: SCDOT, 2021

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Asphalt-Rubber Gap Graded (ARGG) Mixtures

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ARGG Mixture Characteristics

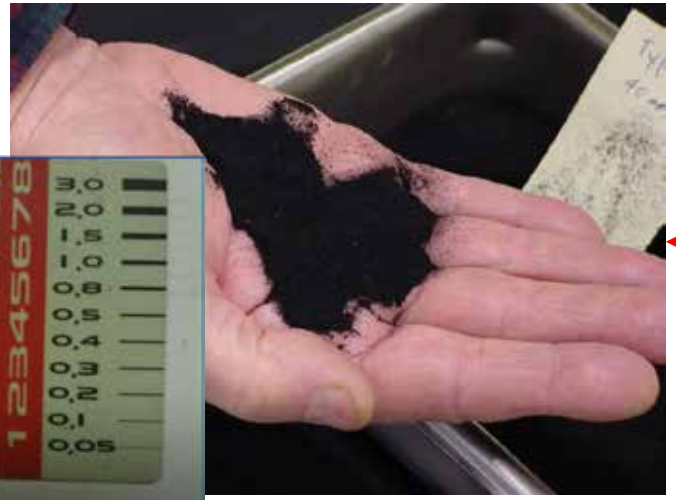
- Asphalt rubber binder.
- Gap-graded asphalt mixture.
- Top-size aggregate from 9.5 to 12.5 mm.
- Thicknesses ranging from 1.2” to 2.4”.
- Designed using slightly modified test methods and specifications.
- Used in a wide range of traffic levels in urban areas, with considerable stop and go traffic.

Source: National Center for Asphalt Technology

ARGG Mixture Background

- Modern use started in the 1960's.
  - Charles McDonald, Materials Engineer, City of Phoenix.
- Originally developed as a surface treatment.
- Work expanded to crack-relief and open-graded layers.
  - Asphalt rubber was field blended.
- Additional work by City of Phoenix and Arizona DOT (ADOT) led to the initial growth of ARGG applications – Primarily in Arizona.
  - Mid 1970's ADOT adopted the use of ground tire rubber (GTR) in pavement interlayers, chip seals, and later as a binder modifier used in open-graded and gap-graded mixes.

Source: James Musselman



ARGG Mixture Terminology

- Recycled tire rubber is sometimes referred to as:
  - Recycled tire rubber (RTR).
  - Ground tire rubber (GTR).
  - Crumb rubber modifier (CRM).
- Three basic methods of blending GTR with asphalt binder:
  1. Wet Process on-site.
  2. Wet Process at terminal.
  3. Dry Process on-site.

Potential Benefits of ARGG Mixtures

- Reduction of:
  - Cracking.
  - Reflective cracking.
  - Thermal cracking.
  - Rutting.
  - Oxidation.
- Provides smooth surfaces.
- Distresses progressed at a much slower rate.
- Beneficially uses waste tires – reduces carbon footprint.

Source: National Center for Asphalt Technology

Production and Construction

Asphalt Rubber Binder Considerations:

- GTR binder should not be used during the reaction period of 45 minutes.
  - Keep GTR binder between 375°F and of 425°F.
- If GTR binder is not used within four hours after the reaction period, heating should be discontinued.
- Reheat no more than twice.
- Maximum mixing temperature is typically 325°F.

Asphalt Rubber Blending Unit

Source: CEI Enterprises

Caltrans
ARGG Mixture Projects

- Asphalt rubber overlays are more cost effective in all areas of California (CP2 2012).
  - The study was based on the conservative assumption that a conventional HMA overlay has a life expectancy of 5 years, whereas an asphalt rubber overlay has a life expectancy of 6 years.
- Cost savings were higher for larger projects, and for highways with higher traffic volumes (such as interstates) due to lower user-delay costs.
- CP2 2015
  - Caltrans could save about 21% by using asphalt rubber.
  - Use of asphalt rubber is cost effective over 84% of the time.

California Pavement Preservation Center (CP2)

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Summary

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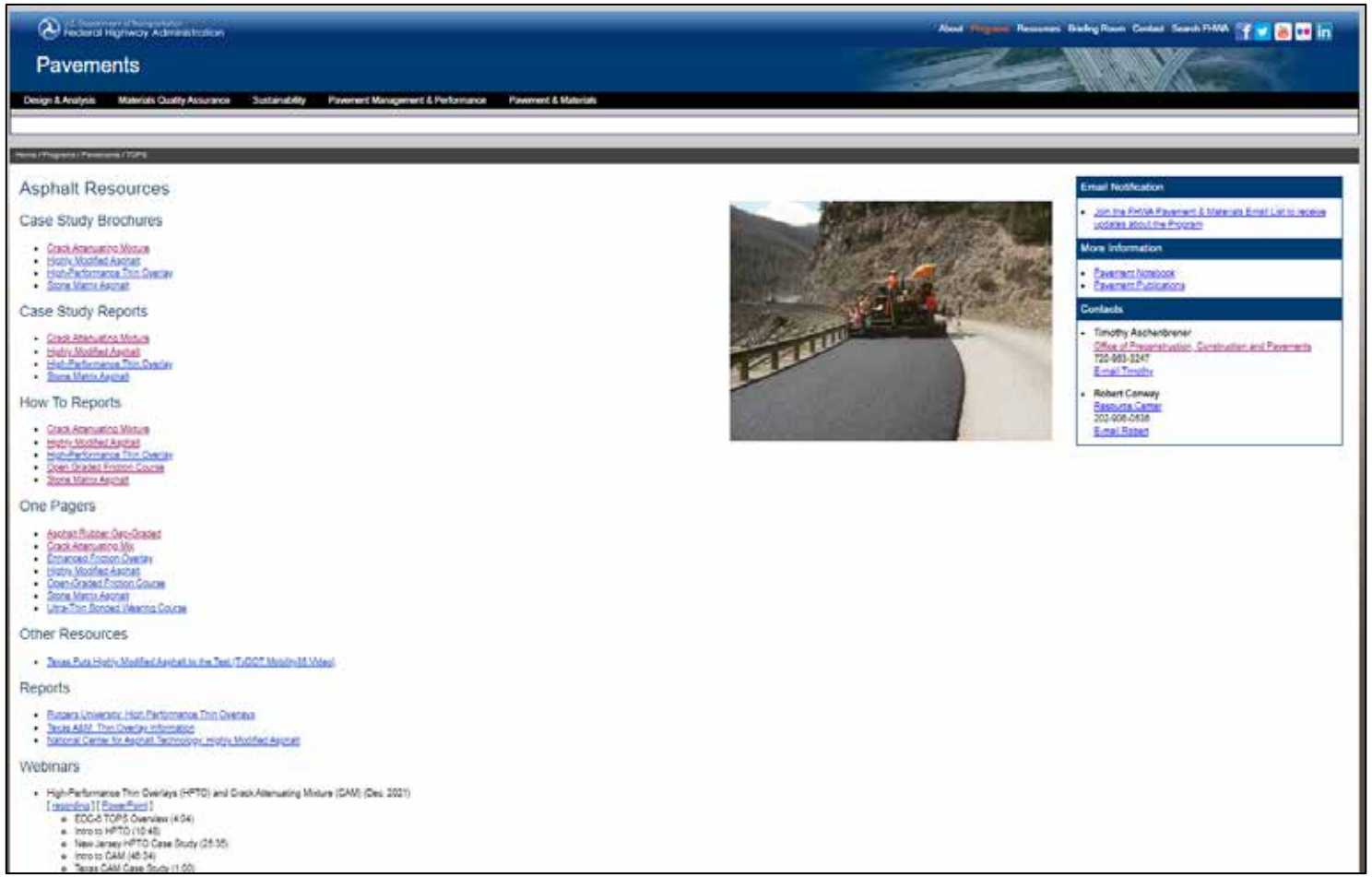
TOPS Website (Asphalt)

- Case Study Reports
- How To Reports
- One Pagers
- Webinars



https://www.fhwa.dot.gov/pavement/tops/asphalt_resources.cfm

Want more information on TOPS?
Contact the TOPS lead:

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Thank you

Questions / Comments

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