EDC-6 TOPS Initiative - The Roles of HiMA™

Northeastern States Materials Engineers’ Association
10/25/2023

Bob Kluttz - Kraton Polymers
Federal Highway Administration
Every Day Counts Program

- A State-based model that identifies and deploys proven, yet underutilized innovations—saving time, money and resources that can be used to deliver more projects.
- Programs run on a two-year cycle starting with EDC-1 in 2011.
- https://www.fhwa.dot.gov/pavement/tops/
Solutions for integrating innovative overlay procedures into practices that can improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.

Asphalt overlay mixtures have also significantly with the use of stone-matrix asphalt (SMA), polymer-modified asphalt (PMA), and other materials and agents that reduce rutting, increase cracking resistance, and extend pavement life.

https://www.fhwa.dot.gov/pavement/tops/
Federal Highway Administration
Every Day Counts – 6
Targeted Overlay Pavement Solutions

- Asphalt Rubber Gap-Graded Mix
- Crack Attenuating Mix
- Enhanced Friction Overlays
- Highly Modified Asphalt
- High Performance Thin Overlays
- Open Graded Friction Course
- Stone Matrix Asphalt
- Ultra-Thin Bonded Wearing Course
Federal Highway Administration
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- In fact, HiMA can be applied to most of the TOPS applications.
- It’s a multi-purpose tool.
Highly Modified Asphalt - Phase Morphology

Bitumen phase  Swollen polymer phase

Bitumen + 2 1/2 % polymer

Bitumen + 5 % polymer

Bitumen + 7 1/2 % polymer

Polymer absorbs bitumen swelling 5-10X
What Is Highly Modified Asphalt?

- Highly Modified Asphalt is exactly what it says, asphalt with more than double the normal amount of SBS polymer.
- This gives a much denser polymer network with up to 10X rutting and fatigue cracking resistance.

Several million tons in over 100 projects around the world have demonstrated superior performance at reduced thickness.
HiMA Specifications North America

<table>
<thead>
<tr>
<th>Standard</th>
<th>AASHTO M 320</th>
<th>AASHTO T 301</th>
<th>AASHTO M 332</th>
<th>AASHTO T 350</th>
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<tr>
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<td>PG specification</td>
<td>Elastic Recovery</td>
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<td>Ohio</td>
<td>PG 88-22M</td>
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<td>Oregon</td>
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<td>Vermont</td>
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<tr>
<td>Washington</td>
<td>PG 76-34</td>
<td>90%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Trials
Starting projects
Significant usage
HiMA Market Applications – Where Does it Add Value?

- **Structural Applications**
  - With a sound base, thinner pavements with lower upfront cost
  - Demonstrated in many field applications & Ohio University APLF
  - With weak base, much longer lifetime can be achieved
- **Thin Overlays**
  - Superior resistance to reflective cracking BUT requires finer, richer mix.
- **Preservation Surfacing such as micro surfacing**
- **Open Grade Mixes for Reduced Raveling**
- **SAMI Layers, e.g., RIL (OK), CAM (TX)**
- **High Stress Applications – ramps, intersections**
- **AASHTOWare® Pavement ME Design works for HiMA designs**
TOPS Initiatives

- So which of the TOPS initiatives are being evaluated in Northeast states?
- It’s a smorgasbord.
First off – thanks to a whole bunch of people!

- Bruce Barkovich
- Tom Bennert
- Rick Bradbury
- Mike Byrne
- Mark Brum
- Ron Corun
- Eshan Dave
- Marshal Klinefelter
- Cheng Ling
- Walaa Mogawer
- Ed Nares
- Casey Nash
- Steve Norton
- Dave Powers
- Tim Ramirez
- Mary Robbins
- Mark Shafer
- Christina Skala
- Eric Thibodeau
- Michael Worden
Connecticut, Massachusetts, Rhode Island

- Similar usage and specifications
- Paver Placed Elastomeric Surface Treatment (PPEST) in RI
- PG 73-34 or PG 76E-34 w/ 80% recovery
- Used as high-performance thin overlay
- Questions on most effective lift thickness
Delaware

- Unexpected application!
- Used to mitigate rutting damage from steel-rimmed buggy wheels and horseshoes
- Projects are successful so far.
- Pennsylvania take note!
Initial HiMA interest was from NCAT result showing similar cracking resistance to ARGG (gap graded GTR modified).

First project was a section of ARGG then a section of HiMA in the southbound lane.
Second year was a HiMA in the northbound lane with a different contractor and binder supplier.

Lower design voids – 3% – to ensure high binder content. Low risk of rutting due to HiMA stiffness and elasticity.

Very early for evaluation, but no reported distress to date.

From the contractor – Production and lay down went well. Compaction and density had no problems if we stayed in the proper temperature zones. Density was easily achieved. Plant production went smoothly after we learned to adjust to the viscosity of the liquid.
Maryland

- Successful overlay projects so far using the VA PG 76E-28 spec
- Limited usage currently with state focus on transit
New Hampshire (similar for Vermont?)

- NHDOT has not performed a TOPS HiMA. They have done two HiMA projects under former FHWA Highways for Life project. NHDOT is planning a TOPS SMA project for next year. NHDOT has utilized an innovative PG 70-34 asphalt mixture with a “recipe” asphalt binder specification (specifying minimum 4% SBS polymer content, so not quite at HiMA level but higher than most typical level, this special provision also requires 4% aromatic oil and binder has to start with neat PG 58-28) to prolong pavement lives and provide added resistance to cracking. Since 2017, 25 paving projects have used this type of mixture.

- Cracking is predominant distress for New Hampshire so that would be the main reason for HiMA application.
- Improved cracking performances that would in-turn result in life cycle cost improvements and reduced maintenance and rehabilitation costs would make HiMA a good choice.
- There were no changes to basic asphalt mixture design (follows standard Superpave mix design procedure).
- Performance has been tracked for the PG 70-34 mixtures since their inception in 2017. These mixtures have shown improved cracking resistances and ride quality as compared to traditional asphalt mixtures.
New York (City)

- Two highlights:
  - 50 blocks of 1st Avenue – NJ HPTO mix with ~76E-34 binder, 2014 construction still showing exceptional performance.
  - George Washington Bridge – NJ BDWSC mix

- Interest is starting to grow on more city street projects.

- New York State, 100% polymer, PG 64E-22 and 64V-22 give them performance improvement to meet budgetary needs.
- And PG76E-28 for a couple more bridge decks.
New Jersey

- Several applications varying in binder spec from standard to highly modified
- Binder Rich Base Course (BRBC)
- Binder Rich Intermediate Course (BRIC)
- High Performance Thin Overlay (HPTO)
- Bridge Deck Waterproof Surface Course (BDWSC)
Pennsylvania

- Six projects planned, two executed.
- SMA surface mix
- Very early for performance comments
- FHWA grant - $700,000 expected to accelerate evaluation
Florida DOT Experience

- Florida HP = PG 76E-22 accounts for about 4-5% of total state tonnage.
- Primary usage is thin overlays and OGFC.
- Funding research projects to quantify performance and benefits.
Best Practices Per ACAF

- Laydown of HP binders doesn’t pose a significant problem as reported thus far, but keep in mind good construction practices:
  - Follow best practices to prevent end of load segregation. HP binders will magnify poor practices!
  - Balance your production rates (plant = trucking = paver = rollers). Keep the mix moving and avoid long stops.
  - Be ready when the trucks arrive on project. Temperature is critical for this mix.
  - Keep compactors tight with paver and adjust rolling pattern as needed to maintain your target density.

- Plant Storage of HP binders is different and requires attention:

Jim Warren, Executive Director, ACAF
HP Storage Per ACAF

- Limited shelf life
- Scheduling & frequent communication with binder supplier
- Do not store indefinitely
- Follow supplier specific handling instructions (storage temperature, storage time, circulation, etc.)
- Best practices will vary with supplier

Jim Warren, Executive Director, ACAF
HP Storage Per Kraton

- Some additional recommendations:
  - Do not overheat. High temperature accelerates viscosity rise.
  - Monitor viscosity daily.
  - Warm mix is good.
  - Definitely circulate, a sidearm mixer may not be adequate.
  - Leftover or high vis product – dilution to PG 76-22 is definitely viable.
  - Do not overheat.
DOT Research

- FDOT sponsor, UNR PI 2019
  - Recommend increasing structural coefficient 0.44 \( \rightarrow \) 0.54
  - [https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/research/reports/fdot-be321-rpt.pdf](https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/research/reports/fdot-be321-rpt.pdf)

- VDOT sponsor, VTRC PI 2020
  - HiMA in SMA construction up to 34% increase in service life

- FDOT sponsor, TTI PI 2019
  - HiMA in OGFC up to 50% increase in service life
New Development!

- It is my pleasure to report that Asphalt Institute is part of a team recently selected for a 5-year FHWA grant titled Development and Deployment of Innovative Asphalt Pavement Technologies. The purpose of the cooperative agreement is to “stimulate, facilitate, and expedite the deployment and rapid adoption of new and innovative technology relating to the design, production, testing, control, construction, and investigation of asphalt pavements.” This is an exciting time to be involved in innovative products that help make asphalt pavements last longer.

Grover Allen - Quarterly Asphalt Institute Engineer’s Report
Thanks!
Questions?

- Bob Kluttz
  Bob.Kluttz@kraton.com
  281-380-1708

- Gary Fitts
  Gary.Fitts@kraton.com
  210-381-6922

- BJ Blackwell
  Richard.Blackwell@kraton.com
  281-414-4516

- https://kraton.com/markets/paving/
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Interlayers

- **Primary purpose:** to delay or prevent distress from reflecting from underlying pavement/material
- **Types:**
  - Fabric/geotextiles
    - Woven, non-woven
    - Typically placed over a leveling course
  - Chip seal-type applications
    - Asphalt rubber/stress absorbing membrane interlayer (SAMI)
    - Underseal
  - Hot mix asphalt
    - Strata® asphalt
    - OK Rich intermediate/rich bottom layer (RIL)
    - TX Crack attenuating mix (CAM)
Section 411/708, 2019 Standard Specifications

Laboratory Mix Design Properties:
- S5 gradation (9.5 mm NMS), min. 5.5% binder content
- \(N_{des} = 50\) gyrations, 97% \(G_{mm}\), VMA ≥ 15.5%, VFA: 73-79%
- Hamburg Wheel Tracking: max 12.5 mm deformation after 20,000 cycles
- PG76E-28 binder grade (HiMA)
HiMA Impact-TxDOT “Crack Attenuating Mixture” (CAM)

- Special Specification (2014) Item 3000

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Fine Mixture ( % Passing by Weight or Volume)</th>
<th>Volumetric Properties</th>
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</thead>
<tbody>
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<td>2&quot;</td>
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<tr>
<td>1-1/2&quot;</td>
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</tr>
<tr>
<td>1&quot;</td>
<td>-</td>
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<tr>
<td>3/4&quot;</td>
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<tr>
<td>1/2&quot;</td>
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<td>3/8&quot;</td>
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<tr>
<td>#8</td>
<td>40.0-65.0</td>
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</tbody>
</table>

Unlike OK & AL, no general requirement for a particular binder grade
Potential Interlayer Concerns

- Multiple operations to mobilize for
  - Added complexity, cost, time
- Specialized work (geotextile placement, asphalt-rubber SAMI application)
- Traffic control during construction
- Cost
- Effectiveness
  - Mixed experience
  - Make sure that the conditions are appropriate
    - Stable underlying structure (minimal vertical movement under loading at cracks)
    - Underlying material resistant to moisture damage
    - Correct any problem with subsurface drainage.
“Rich Intermediate Layer” (RIL)

- ODOT Specifications, Section 411(j)
- Characteristics: Flexible, impermeable, provides structural benefit
- Small nominal maximum aggregate size, high binder content, low air voids mixture using highly modified asphalt binder (HiMA)
  - PG76E-28
- Purpose: to resist reflection of underlying cracks through the surface while providing additional pavement structure and a leveling/profiling opportunity
- First used at the NCAT Test Track in Section N8
ODOT History of RIL Use: 2012-2022

- Steady increase since 2018
- Used in all ODOT Districts
  - Most in District 1
- Projects ranging from county roads to Interstate highways
Iowa DOT Hot Mix Asphalt Interlayer Specification

- PG 58-34E binder
- No RAP
- AASHTO T-321 Min 100,000 cycles to failure at 2000 microstrain
- In use since 2014, mostly for overlaying jointed concrete pavement

N_{des} = 50 gyrations, 98% G_{mm}
Film Thickness > 8.0 μm

https://iowadot.gov/erl/current/IM/content/510aa.htm

≈ ODOT RIL/S5 Gradation
Alabama DOT Projects

1) I-59/-20, Tuscaloosa Co., 2016-7
2) I-459, Jefferson Co., 2018
3) I-85, Macon Co., 2021
4) I-59, Etowah & Dekalb Co.’s, 2022

- 9.5 mm NMS Superpave, designed at 2% air voids requiring HiMA (PG76-22E per ALDOT specs)
- Used to delay/prevent reflection cracking
Alabama I-59/20

- Extensive longitudinal cracking
  - About 1/3 of cracks extended beyond top 4 inches of pavement
  - Deflection (FWD) analysis suggested the need for additional pavement thickness
- 17 bridges within project limits complicated things
  - Very costly to raise the surface profile to allow for additional structure
  - Estimated to cost almost $8.7 million just to raise bridge surfaces
- Drew from NCAT experience in Section N8
Alabama I-59/20 Rehabilitation

From Braden Smith (Hunt Refining) at 2018 SEAUPG Meeting

Total thickness 8 ¼”
Alabama I-59/20-Conditions

- Opened in 2016, no distress reported by ALDOT in 2020
- Roughness difficult to assess due to bridges, but no change evident
- So far, so good!
NCAT’s Test Track—the only high-speed, full-scale accelerated pavement testing facility in the world—is a 1.7-mile oval with experimental sections sponsored by highway agencies and the transportation industry.

Want to get involved? Contact us for information on how to become a sponsor.

https://www.eng.auburn.edu/research/centers/ncat/testtrack/index.html
NCAT 2006 Construction, Sections N8 & N9, Oklahoma DOT

- ODOT tested the perpetual pavement concept in anticipation of building SH 152 southwest of OKC
  - Reconstructed the embankment for N8 and N9 to approximate central Oklahoma conditions
  - Both test sections included a “Rich Bottom Layer,” and SMA surface
- Sections N8 (10 in., total) and N9 (14 in., total), Section N9 – no distress, as expected. N8 was severely distressed and required rehabilitation for safety and operational purposes
  - First rehabilitation attempt included milling 5 in., replacing with similar materials as before (as per typical ODOT rehab strategy), placing a geotextile on top of the dense-graded leveling course
  - Cracking observed after 2.7 million ESAL, then deteriorated rapidly requiring additional rehabilitation

NCAT Section N8 – June 29, 2010

- 10” pavement built in Aug. 2006
- 5” rehabilitation in Aug. 2009
- 10 months old
NCAT Section N8, Oklahoma DOT

- Excellent performance observed on the adjacent test section (N7), which was a thin (5¾-inch) pavement using “highly-modified” asphalt (HiMA) binder
- Milled 6 inches, replaced with a like thickness of mixtures using HiMA binder
  - This approach could be done very quickly and easily
  - Included a 1-inch “rich HPM” (RIL) lift to retard reflection cracking—designed to similar volumetric requirements as rich bottom layer mixture.

NCAT Report 16-04
https://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep16-04.pdf
NCAT Section N8 Rehabilitation-Results

- Roughness, rutting stabilized after HiMA rehabilitation
- No cracks observed until more than 15 million ESAL
- A viable option for rapid rehabilitation of Interstates or other pavements subjected to heavy vehicle traffic

NCAT Report 16-04
https://www.eng.auburn.edu/research/centers/ncat/files/technical-reports/rep16-04.pdf
I-40, Caddo County (approx. MP 102.2-104.2)

- Feb-April 2012
- Milled 5 inches, replaced with:
  - 1½ in RIL, PG76-28E (HiMA)
  - 5 in S3, PG76-28E, in two lifts
  - 1½ in S5, PG76-28E
  - ¾” OGFC (PG76-28, not HiMA)
Oklahoma DOT HiMA Specification, PG76E-28

### 708.03 ASPHALT MATERIALS

Provide asphalt cement in accordance with AASHTO M 320 or M 332 with additional specifications as detailed in Table 708:2 as required by the Contract.

<table>
<thead>
<tr>
<th>Test</th>
<th>PG 58-28 (PG 58S-22)</th>
<th>PG 64-22 (PG 64S-22)</th>
<th>PG 70-28 (PG 64V-28)</th>
<th>PG 76-28 (PG 64E-28)</th>
<th>PG 88-28 (PG 76E-28)</th>
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<td>Rₚ₃.2, %</td>
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<td>≥ 95</td>
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</tbody>
</table>

Note: Asphalt binder suppliers will provide handling requirements for their products to the asphalt producer.

² May be allowed if 100x micrographs of PG 76E-28 sulfur cured at 2, 4, and 6 hours indicates a uniform dispersion of polymer and approved by the Materials Division Engineer.
Oklahoma DOT Historical Cost Data

- Oklahoma Department of Transportation publishes “Average Price History,” available online
- Compare RIL with Fabric Interlayer + S5 leveling

https://www.odot.org/contracts/avgprices/index.php
### Cost Comparison: RIL vs. Fabric + Leveling

<table>
<thead>
<tr>
<th>Item</th>
<th>Low bid</th>
<th>Avg. 3 low bids</th>
</tr>
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<tbody>
<tr>
<td>S411(J), RIL (1.25”)</td>
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<td>$120.35/ton</td>
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<tr>
<td>S407(D), Tack Coat (NT), (0.10 gal/sy)</td>
<td>$3.28/gal</td>
<td>$3.32/gal</td>
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<tr>
<td>S409, Fabric</td>
<td>$2.33/sy</td>
<td>$2.28/sy</td>
</tr>
<tr>
<td>S409, Bit. Binder</td>
<td>$3.99/gal</td>
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<tr>
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<td>$80.29/ton</td>
<td>$85.63/ton</td>
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<td>S411 (D), Type S5 (PG76-28)</td>
<td>$95.20/ton</td>
<td>$102.40/ton</td>
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</tbody>
</table>

Comparison: RIL vs. Fabric + Leveling*

- RIL Cost = RIL (1.25 in) + Tack (trackless tack @ 0.10 gal/sy)
- Fabric = Fabric + Bituminous Binder (@ 0.225 gal/sy) + S5 (1.25 in)

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Low Bid</th>
<th>Avg. 3 lowest</th>
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<tbody>
<tr>
<td>1.25 in Rich Intermediate Layer (RIL)</td>
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<tr>
<td>Fabric, 1.25 in. S5 (PG64-22)</td>
<td>$8.75/sy</td>
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<td>Fabric, 1.25 in. S5 (PG76-28)</td>
<td>$9.77/sy</td>
<td>$10.34/sy</td>
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</table>

*Note that this does **not** account for differences in mobilization, traffic control or other items
I-40, Caddo County

- Avg. 2020 IRI: 49.97 in/mi (EB), 47.81 in/mi (WB)*
- 2021 AADT = 29,600 with 36% trucks (7% single-unit, 29% combination)

“S-Curve” – Effect of increasing SBS content

Discontinuous Polymer Phase

Continuous Polymer Phase

Softening point T R&B [°C]
“S-Curve” – Effect of increasing SBS content

- Continuous Bitumen Phase
- Continuous Polymer Phase
- Highly Modified, HPG

Softening point T R&B [°C]

SBS Content [%]

- PG70-22
- PG76-22
- PG76-28
- PG82-22
- Highly Modified, HPG