19th Arizona Pavements/Materials Conference

Rich Intermediate Layer

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Agenda

- Approaches to delay/prevent reflection cracking in overlays
- NCAT Test Track-Section N8
- Oklahoma I-40, ODOT experience
- Other examples
- Highly-Modified Asphalt binder

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®
    - Rich intermediate/rich bottom layer

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.

Oklahoma DOT "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

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: milled 5 in., replaced 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

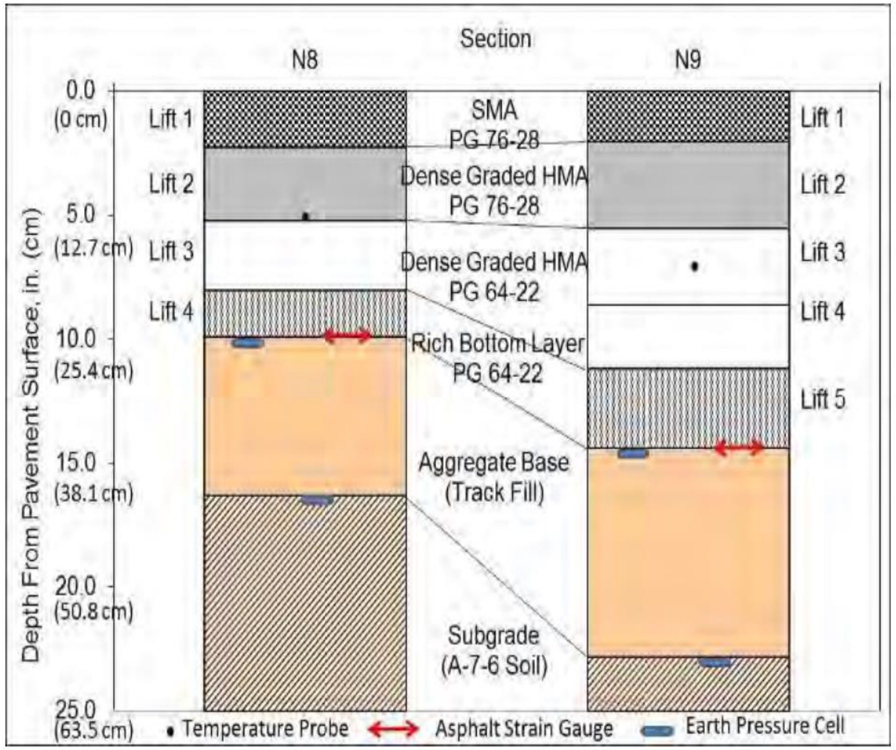

Figure 1 Structural Cross Sections and Instrumentation (*1*)

Timm, D. H., D. Gierhart, and J. R. Willis. Strain Regimes Measured in Two Full Scale Perpetual Pavements. Proc., International Conference on Perpetual Pavement, Columbus, OH., 2009.

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.

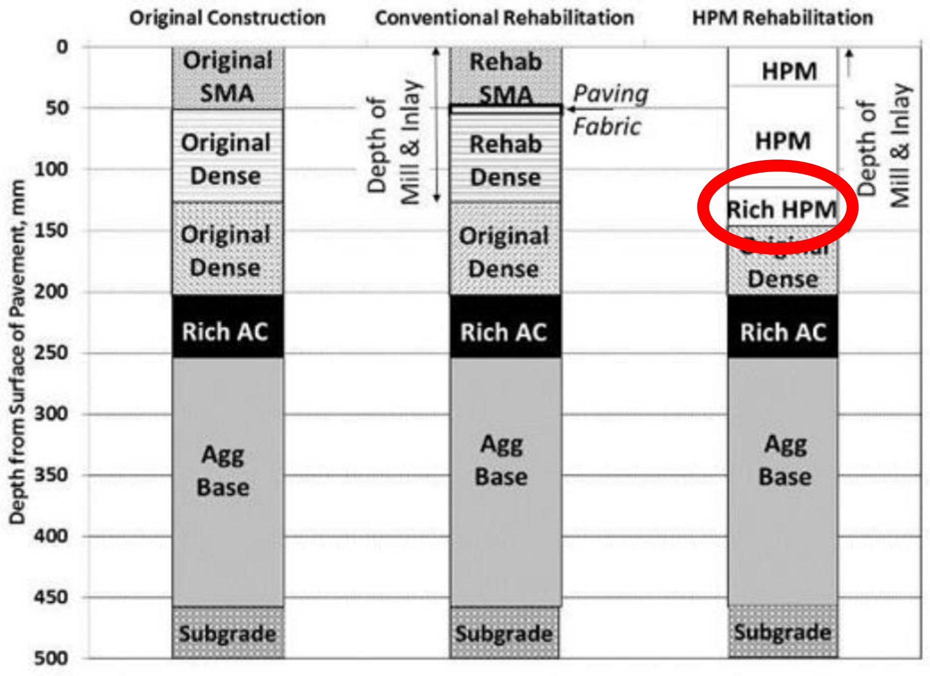

Figure 2 N8 Cross Section History (3)

NCAT Report 16-04

https://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep16-04.pdf

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NCAT Section N8 Rehabilitation-Results

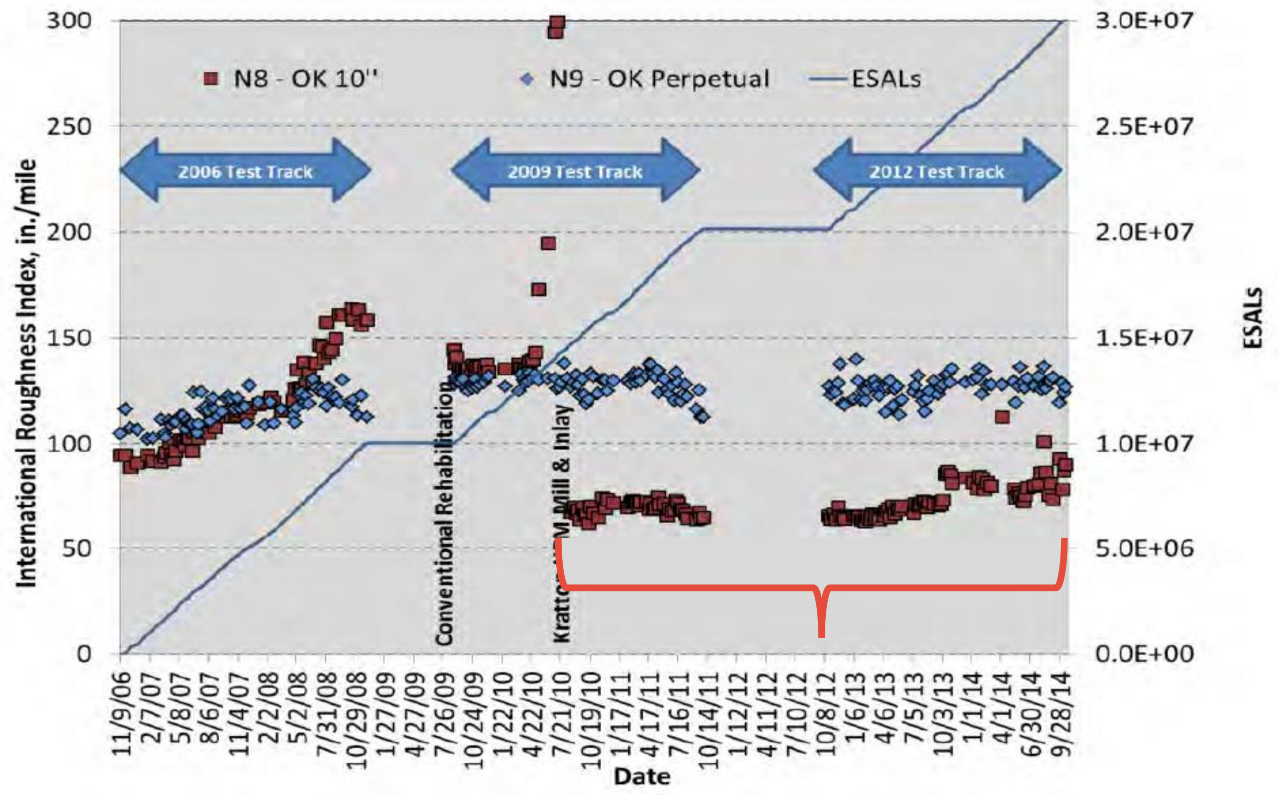


Figure 4 IRI Evaluation of Oklahoma Perpetual Pavement Sections

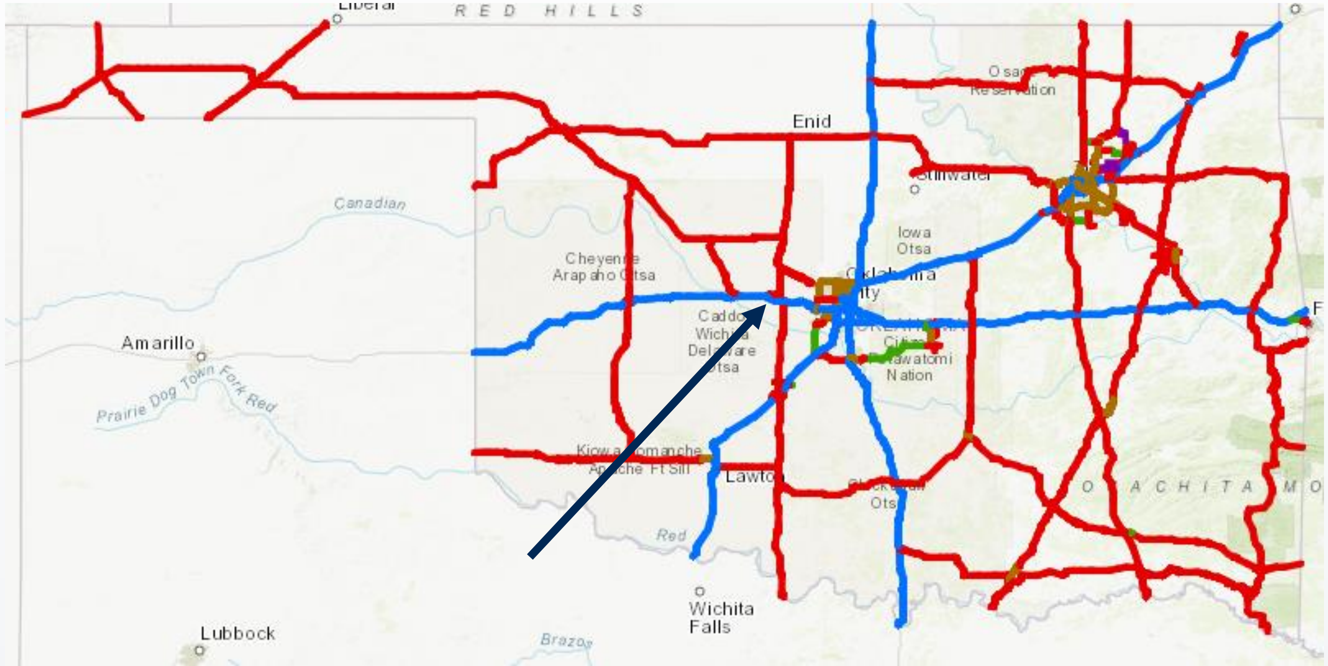
NCAT Report 16-04

https://www.eng.auburn.edu/research/centers/ncat/files/technical-reports/rep16-04.pdf

- 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

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)



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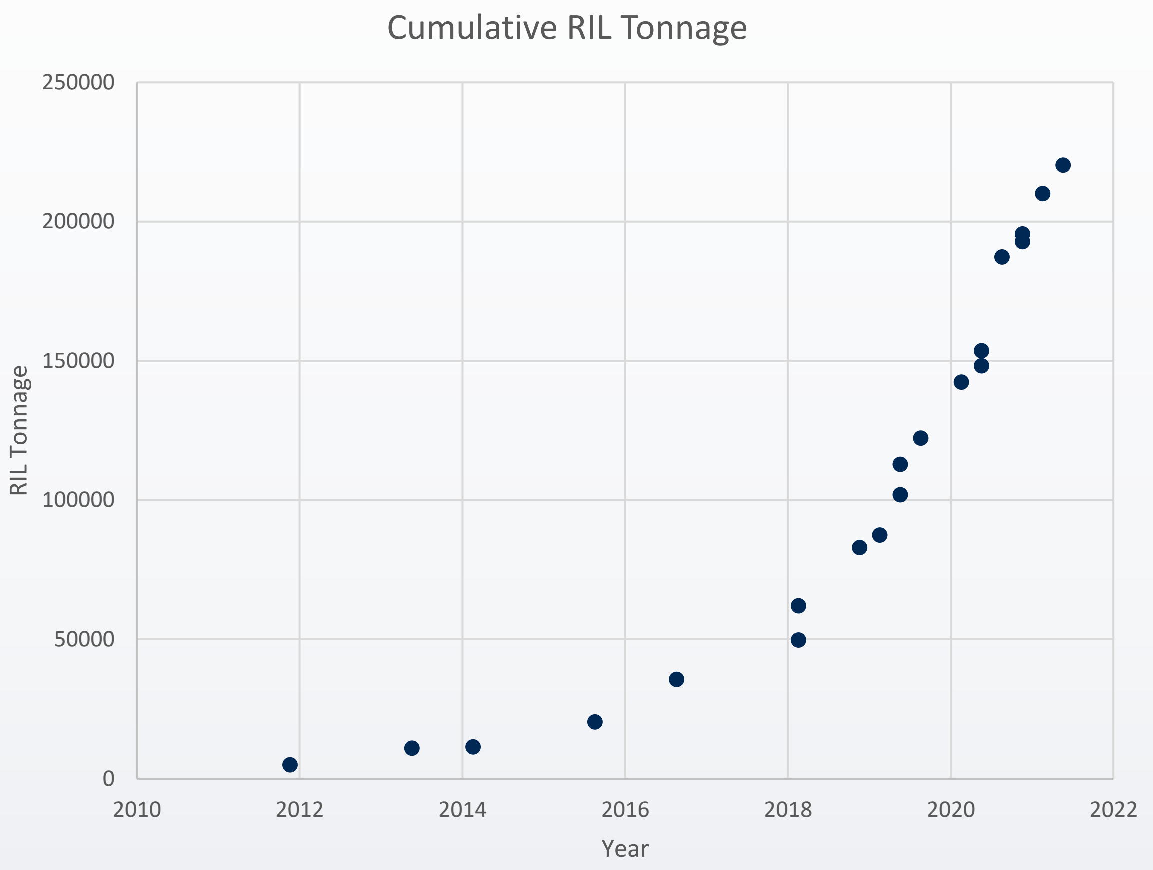
I-40, Caddo County

- 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)

* https://spotlight-okdot.hub.arcgis.com/apps/master-roadway-bridge-data-viewer/explore

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



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

Oklahoma Department of Transportation
Item Price History from July 01, 2019 to December 31, 2020

January 11, 2021

Weighted Average Item Price Report
By Item, Region, and Quarter

Item	District	Quarter	Number of Occur's	Total Quantity	Total Dollars	Avg Awarded Price	Avg of Low 3 Bidders
411(D) 5965 / SUPERPAVE, TYPE S5(PG 76-28 OK) / TON							
	03	2020Q1	1	250.00	$ 25,025.00	$ 100.10	$ 108.39
	04	2020Q2	1	35.00	$ 41,626.90	$ 1,189.34	$ 687.17
			2	285.00	$ 66,651.90	$ 233.87	$ 157.80
411(D) 5970 / SUPERPAVE, TYPE S5(PG 70-28 OK) / TON							
	03	2020Q1	2	25,386.00	$ 2,174,090.40	$ 85.64	$ 94.42
		2020Q2	1	2,768.02	$ 329,394.38	$ 119.00	$ 111.77
	04	2019Q4	2	6,225.40	$ 702,172.40	$ 112.79	$ 111.04
	08	2020Q2	1	784.00	$ 76,557.60	$ 97.65	$ 97.65
			6	35,163.42	$ 3,282,214.78	$ 93.34	$ 98.04
411(D) 5975 / SUPERPAVE, TYPE S5(PG 64-22 OK) / TON							
	02	2020Q2	4	24,947.00	$ 2,133,329.45	$ 85.51	$ 87.02
	03	2019Q3	2	119.70	$ 21,405.00	$ 178.82	$ 316.32
		2020Q1	2	13,605.00	$ 1,112,497.50	$ 81.77	$ 90.18
		2020Q3	1	4.50	$ 2,250.00	$ 500.00	$ 666.67
		2020Q4	3	6,582.00	$ 518,130.00	$ 78.72	$ 83.67
	05	2019Q3	1	2,330.00	$ 229,505.00	$ 98.50	$ 101.00
	06	2020Q4	2	5,542.97	$ 663,343.82	$ 119.67	$ 119.67
			15	53,131.17	$ 4,680,460.77	$ 88.09	$ 90.11
411(J) 6410 / (SP) RICH INTERMEDIATE LAYER / TON							
	01	2020Q2	1	5,930.00	$ 696,478.50	$ 117.45	$ 120.73
		2020Q3	2	33,593.00	$ 3,390,107.00	$ 100.92	$ 104.98
	02	2020Q2	1	5,400.00	$ 761,400.00	$ 141.00	$ 137.10
	04	2020Q1	2	20,018.00	$ 1,983,916.00	$ 99.11	$ 105.06
	05	2020Q4	1	5,611.00	$ 585,058.97	$ 104.27	$ 105.66
	06	2020Q4	1	2,735.97	$ 341,996.25	$ 125.00	$ 125.00
	08	2019Q3	1	9,505.00	$ 817,430.00	$ 86.00	$ 94.08
			9	82,792.97	$ 8,576,386.72	$ 103.59	$ 107.38

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Cost Comparison: RIL vs. Fabric + Leveling

Item	Low bid	Avg. 3 low bids
S411(J), RIL (1.25”)	$114.10/ton	$120.35/ton
S407(D), Tack Coat (NT), (0.10 gal/sy)	$3.28/gal	$3.32/gal
S409, Fabric	$2.33/sy	$2.28/sy
S409, Bit. Binder	$3.99/gal	$4.54/gal
S411 (D), Type S5 (PG64-22), 1.25”	$80.29/ton	$85.63/ton
S411 (D), Type S5 (PG76-28)	$95.20/ton	$102.40/ton

Source: Oklahoma DOT(https://www.odot.org/contracts/avgprices/index.php), March 14, 2022 Price History

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)

Alternative	Low Bid	Avg. 3 lowest
1.25 in Rich Intermediate Layer (RIL)	$8.17/sy	$8.60/sy
Fabric, 1.25 in. S5 (PG64-22)	$8.75/sy	$9.19/sy
Fabric, 1.25 in. S5 (PG76-28)	$9.77/sy	$10.34/sy

*Note that this does not account for differences in mobilization, traffic control or other items

ODOT Specification Requirements, RIL

- 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)

Table 411:7
Mix Design Properties of Laboratory Molded Non-Superpave Specimens

Property	RIL
Number of SGC Gyrations	50
Required Density, *% of G_{mm}*	97.0
VMA [a], %	≥15.0
TSR minimum	0.80
Draindown, %	—
Permeability, *cm/s* × 10^{-5}	≤12.5
Hamburg rut depth, *mm*	≤12.5[b]

[a] VMA is based on the bulk specific gravity of the aggregates.
[b] Based on PG binder type.

Special Provision 411-015

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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 708:2
AASHTO M 332 Requirements for Asphalt Cement

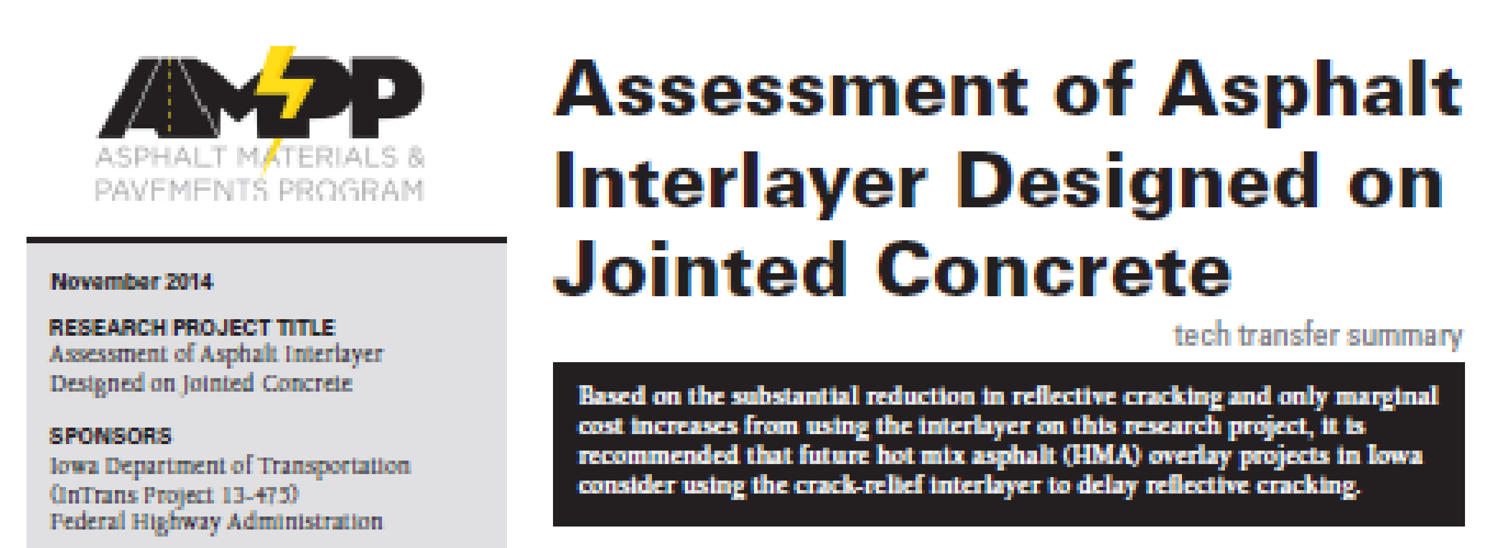
Test	PG 58-28 (PG 58S-22)	PG 64-22 (PG 64S-22)	PG 70-28 (PG 64V-28)	PG 76-28 (PG 64E-28)	PG 88-28 (PG 76E-28)
$J_{nr}3.2$, kPa[1]	M 332	M 332	M 332	M 332	M 332
R3.2, %	—	—	≥ 50	≥ 80	≥ 95
PAV DSR	M 332	M 332	M 332	M 332	M 332

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

[1] 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.

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



ASPHALT MATERIALS & PAVEMENTS PROGRAM

November 2014

RESEARCH PROJECT TITLE
Assessment of Asphalt Interlayer Designed on Jointed Concrete

SPONSORS
Iowa Department of Transportation (InTrans Project 13-473)
Federal Highway Administration

Assessment of Asphalt Interlayer Designed on Jointed Concrete

tech transfer summary

Based on the substantial reduction in reflective cracking and only marginal cost increases from using the interlayer on this research project, it is recommended that future hot mix asphalt (HMA) overlay projects in Iowa consider using the crack-relief interlayer to delay reflective cracking.

https://intrans.iastate.edu/app/uploads/2018/03/asphalt_interlayer_on_jointed_concrete_t2.pdf

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

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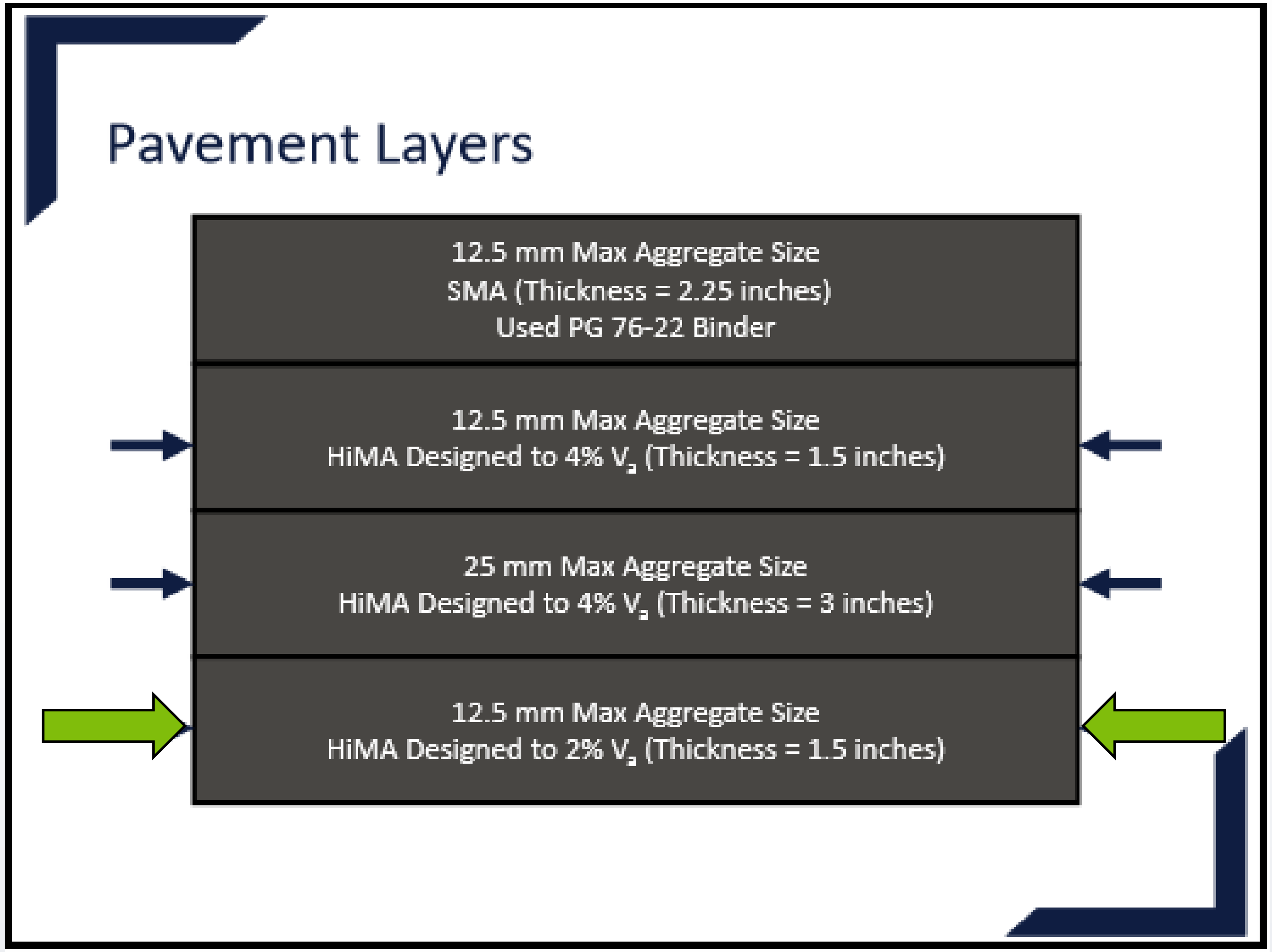
Alabama I-59/20

- Opened in 1970, rehabilitated in 1983, 1990 and 2001
- 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 on Section N8

Alabama I-59/20 Rehabilitation

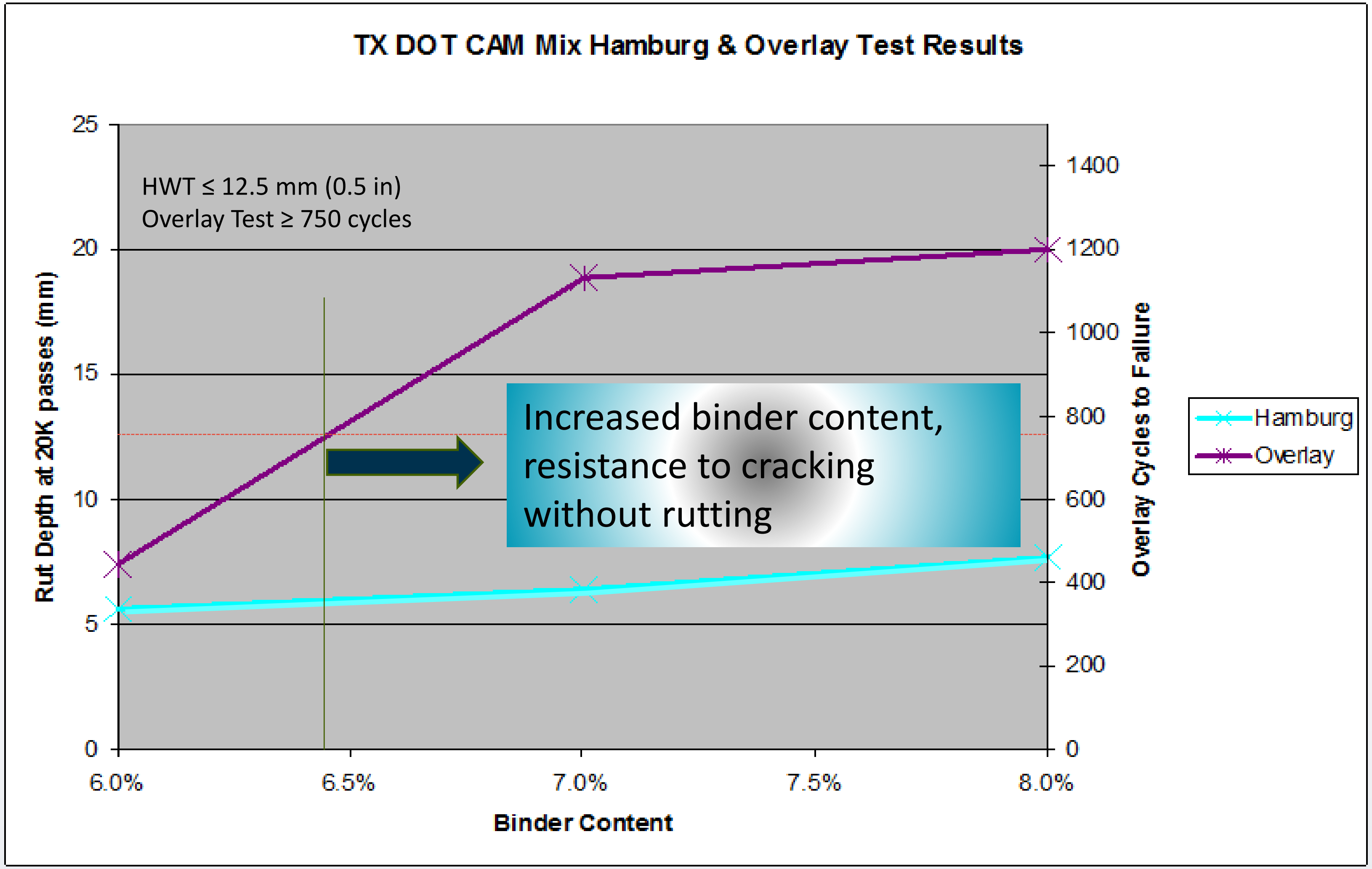


From Braden Smith (Hunt Refining) at 2018 SEAUPG Meeting

HiMA (Highly-Modified Asphalt) Binder

- Not a product, but a binder grade
  - Examples include PG76E-28 (Oklahoma), PG76-28E (HP)(Virginia), High Polymer (Florida), HPG (Texas)
  - Distinguished by high MSCR recovery/low compliance at elevated temperature
- Results in higher SBC content (2X-3X) that of conventional polymer-modified binder grades
- Enables the use of high binder content without instability or bleeding

TxDOT Item 3000, Crack Attenuating Mixture (CAM)



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“S-Curve” – E

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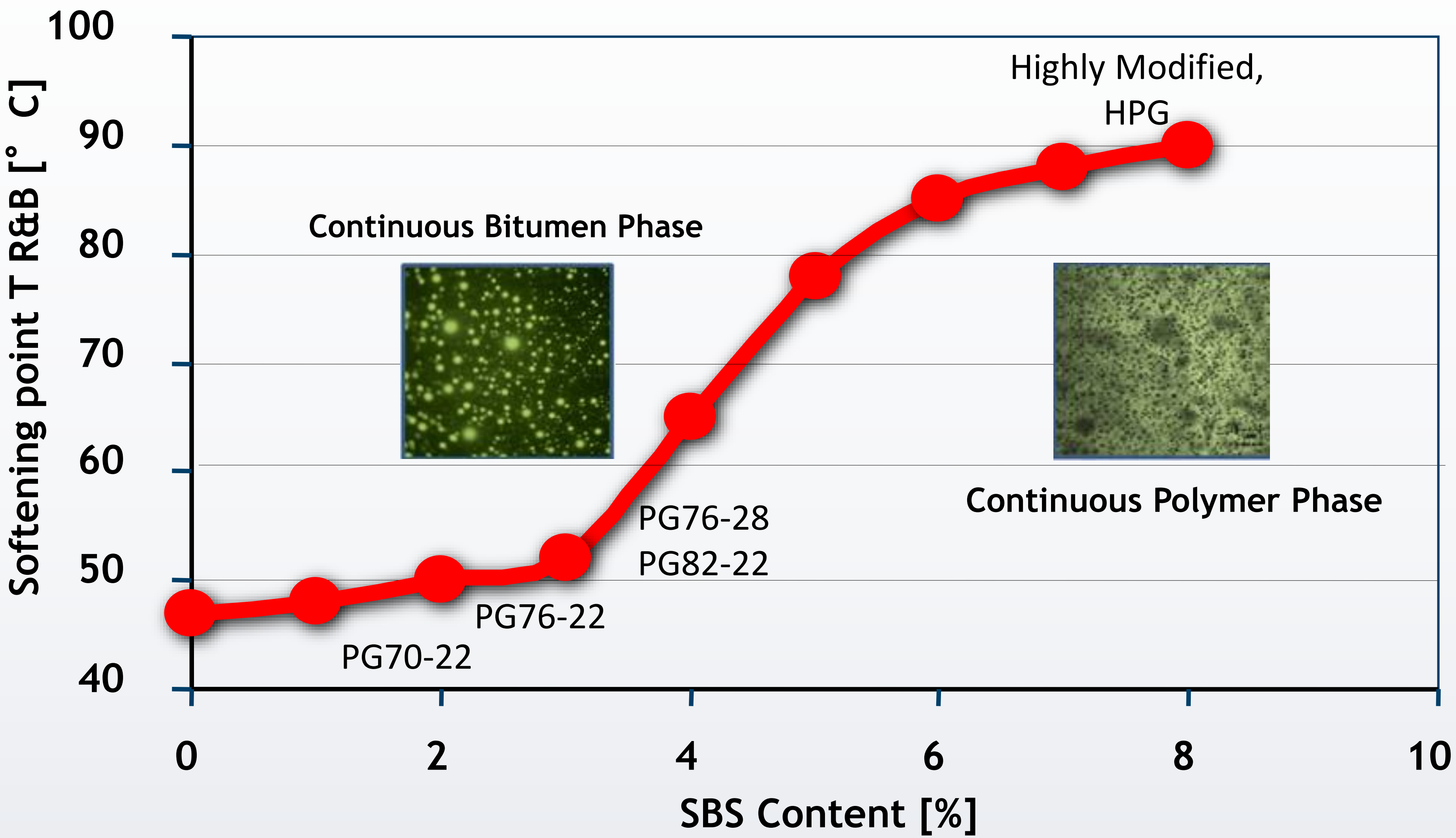
"S-Curve" – Effect of increasing SBS content



FHWA "Every Day Counts" Initiative, EDC-6

- Targeted Overlay Pavement Solutions (TOPS)
- Solutions for integrating innovative overlay procedures into practices that can improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.
- Approximately half of all infrastructure dollars are invested in pavements, and more than half of that investment is in overlays. By enhancing overlay performance, State and local highway agencies can maximize this investment and help ensure safer, longer-lasting roadways for the traveling public.

State of the Practice

Recent improvements to design methods, interlayer technology, slab geometry, and concrete mixtures have broadened concrete overlay surface treatment applicability, reliability, sustainability, and cost-effectiveness. A joint effort by Georgia, Iowa, Kansas, Michigan, Minnesota, Missouri, North Carolina, and Oklahoma resulted in the development of an improved design procedure for jointed unbonded concrete overlays on either concrete or composite pavements.

For asphalt overlays, several State departments of transportation (DOTs) have adopted SMA due to increased service life and performance. The Maryland, Alabama, and Utah DOTs each used over 1 million tons of SMA during a 5-year period. DOTs in Florida, Georgia, New Jersey, New York City, Tennessee, and Virginia found highly modified asphalt in thin overlays is more resistant to reflective cracking. It has increased pavement life by two to four times for DOTs in Alabama and Oklahoma.


U.S. Department of Transportation Federal Highway Administration

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Every Day Counts
Innovation for a Nation on the Move

EDC-6 Innovations *(2021-2022)*

Crowdsourcing for Advancing Operations

Crowdsourced data can be obtained whenever and wherever people travel, allowing agencies to capture in real time what happens between sensors, in rural regions, along arterials, and beyond jurisdictional boundaries. Agencies at all levels can use crowdsourced data integrated from multiple streams to optimize roadway use for reduced congestion and increased safety and reliability.

e-Ticketing and Digital As-Builts

Converting paper-based materials ticketing systems and as-built plans into electronic (e-Ticketing) workflows and digital as-builts enhances the accessibility of highway project data. e-Ticketing improves the tracking, exchange, and archiving of materials tickets. Digital information, such as 3D design models and other metadata, enhances the future usability of as-built plans for operations, maintenance, and asset management.

Next-Generation TIM: Integrating Technology, Data, and Training

Traffic Incident Management (TIM) programs aim to shorten the duration and impact of roadway incidents and improve the safety of motorists, crash victims, and responders. New tools, data, and training mechanisms are available that can benefit both new and existing TIM programs, including local agency and off-interstate applications.

Strategic Workforce Development

The demand for highway construction, maintenance, and operations workers is growing, while at the same time, emerging technologies require these workers to have new skills. The Highway Construction Workforce Partnership has developed new resources and innovative strategies for identifying, training, and placing individuals in the Contractors' workforce filling the construction jobs that support the Nation's highway system.

Targeted Overlay Pavement Solutions

Pavement overlays represent a significant portion of highway infrastructure dollars. State and local highway agencies can maximize this investment and help ensure safer, longer-lasting roadways by employing innovative overlay procedures that will improve pavement performance, lessen traffic impacts, and reduce the cost of pavement ownership.

UHPC for Bridge Preservation and Repair

Ultra-high performance concrete (UHPC) is a new material for bridge construction that has become popular for field-cast connections between prefabricated bridge elements. Bridge preservation and repair is an emerging and promising application for UHPC. UHPC-based repair solutions are robust, and offer superior strength, durability, and improved life-cycle cost over traditional methods. State and local agencies can deploy UHPC for bridge preservation and repair to maintain or improve bridge conditions.

Virtual Public Involvement

Public engagement during transportation project planning and development helps agencies identify issues and concerns early in the process, which can ultimately accelerate delivery. Virtual public involvement strategies supplement traditional face-to-face information sharing with technology platforms that increase the number and variety of methods agencies use to inform the public, receive feedback, and collect and consider comments.

Contact

View list of EDC-6 contacts

EDC Rounds

EDC-1 *(2011-2012)*
EDC-2 *(2013-2014)*
EDC-3 *(2015-2016)*
EDC-4 *(2017-2018)*
EDC-5 *(2019-2020)*

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https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/

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HiMA Applications

- Improved OGFC performance
  - TTI study for FDOT estimates increase of ~50% in service life compared to conventional PMA
- Greater resistance to reflection cracking in dense-graded mixtures and SMA
  - Virginia DOT, FDOT
- Increased AASHTO layer coefficient (0.54 vs 0.44) for Florida DOT
- More resistant to studded tire wear-Alaska DOT&PF research and experience
- FDOT-over 700,000 mix tons using High Polymer since 2017
- TxDOT has let and awarded two projects on I-35 in Austin using “HPG” (HiMA) in SMA, Laredo District also using
- Oklahoma DOT-another major rehab project on I-40 coming up this fiscal year

https://www.fhwa.dot.gov/innovation/innovator/issue93/page_03.html

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Thanks!

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