KRATON™

Oklahoma's Rich Intermediate Layer

Gary L. Fitts, P.E., Kraton Corporation

PA Asphalt Pavement Assoc.

PAPA

Pennsylvania rides on us... ASPHALT

Global Specialty Chemical Company

9 Innovation Centers

13 Manufacturing Locations

6 Regional Headquarters

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Styrenic Block Copolymers & Pine Chemicals

70+ Countries

1800+ Employees

700+ Customers

6,000+ Suppliers

$37M Innovation Investment Annually

>1,000 Patents

100 Years

Ground Breaking Innovations

Agenda

- EDC-6, TOPS
- Interlayers
- Rehabilitation of Oklahoma test section N8 at the NCAT Test Track (2009)
- I-40 rehabilitation (2012)
- RIL applications, since 2012
- Specifications, examples from other states

FHWA "Every Day Counts" Initiative, EDC-6

- Targeted Overlay Pavement Solutions (TOPS)
- Approximately half of all infrastructure dollars are invested in pavements, and more than half of that investment is in overlays.
- Solutions for integrating innovative overlay procedures into practices that can improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.

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.


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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)

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

EDC-6 TOPS-Asphalt Overlay Categories

- Asphalt Rubber Gap-Graded
- Crack Attenuating Mixture
- Enhanced Friction Overlay
- Highly Modified Asphalt
- High-Performance Thin Overlay
- Open-Graded Friction Course
- Stone Mix Asphalt (aka Stone Matrix Asphalt, or SMA)
- Ultra-Thin Bonded Wearing Course

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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®
    - 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.

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

About NCAT | Test Track | Pavement Preservation | Education & Training | Our Research

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

GET IN TOUCH

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, anticipating several greenfield highway projects
- Two test sections: N8 (not perpetual) and N9 (perpetual)
- N8 experienced fatigue cracking and structural rutting, requiring rehabilitation

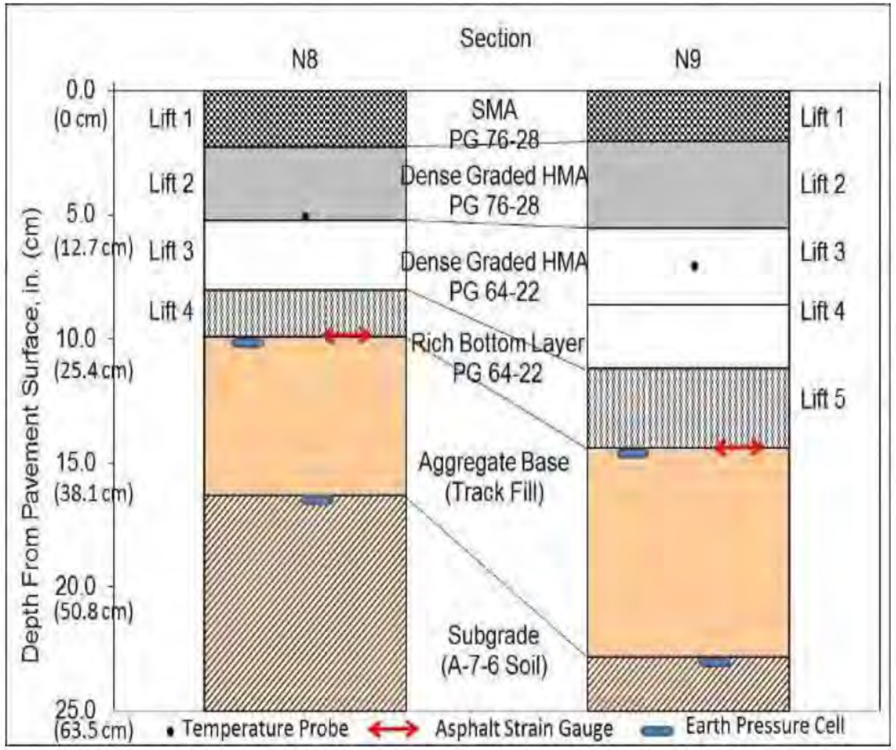

Figure 1 Structural Cross Sections and Instrumentation (*1*)

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, 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
  - Rapid, straightforward construction
  - Included a 1-inch “rich HPM” (RIL) lift

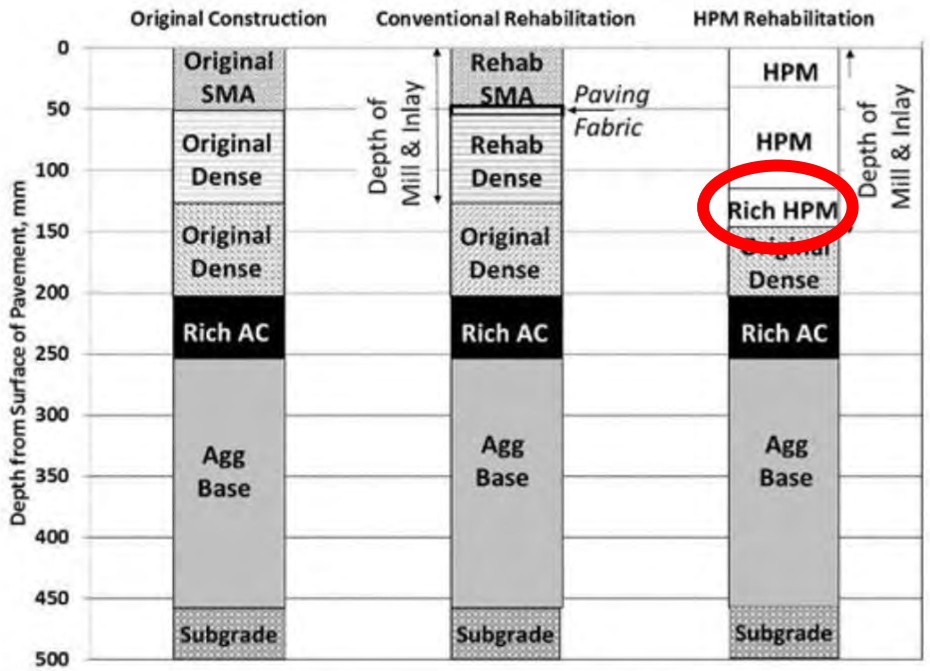

Figure 2 N8 Cross Section History (3)

NCAT Report 16-04

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

NCAT Section N8 – June 29, 2010

- 10” pavement built in Aug. 2006
- 5” rehabilitation in Aug. 2009

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NCAT Section N8 Rehabilitation-Results

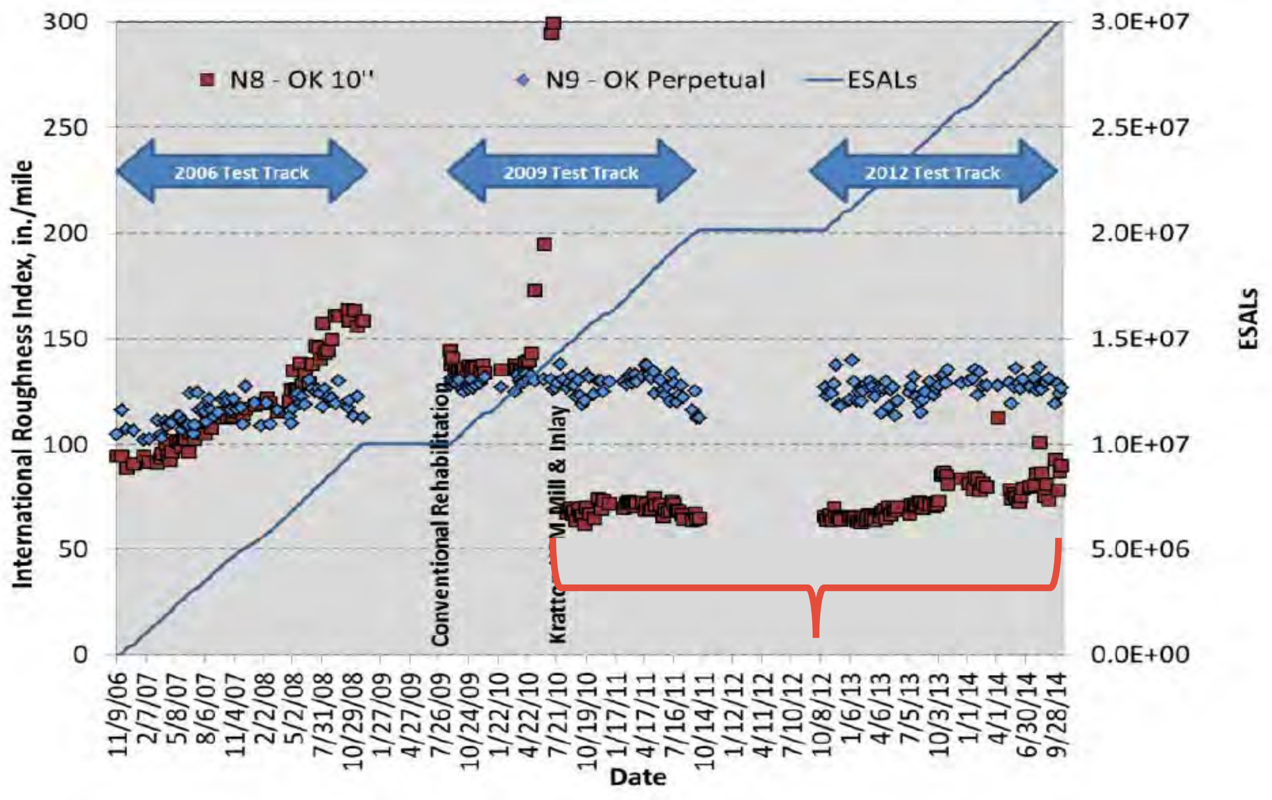

Figure 4 IRI Evaluation of Oklahoma Perpetual Pavement Sections

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 after >15 million ESAL
- A viable option for rapid rehabilitation of Interstates or other pavements subjected to heavy vehicle traffic

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Construction History, I-40 MP 102.2-104.2

Year	Work Description
1962	Original construction, consisting of: 4.5 in, asphalt concrete 8 in, sand asphalt 6 in, stabilized base
1975	1.5 in. asphalt concrete overlay
1980	OGFC (probably 0.75 in) Petromat (paving fabric) Asphalt concrete leveling course (probably around 1.5 in)
1991	3 in, asphalt concrete, Type B Cold milling (no thickness indicated)
1996	2.5 in, asphalt concrete Type B, polymer-modified asphalt binder 2 in cold milling (outside lanes)
2007	Novachip (typically 0.5-0.75 in) 2 in hot in-place recycling

I-40, Caddo County (approx. MP 102.2-104.2)

- Feb-April 2012
- Milled 5 inches, replaced with:
  - 1½ in (38 mm) RIL, PG76-28E (HiMA)
  - 5 in (127 mm) S3, PG76-28E, in two lifts
  - 1½ in (38 mm) S5, PG76-28E
  - ¾” (19 mm) OGFC (PG76-28, not HiMA)

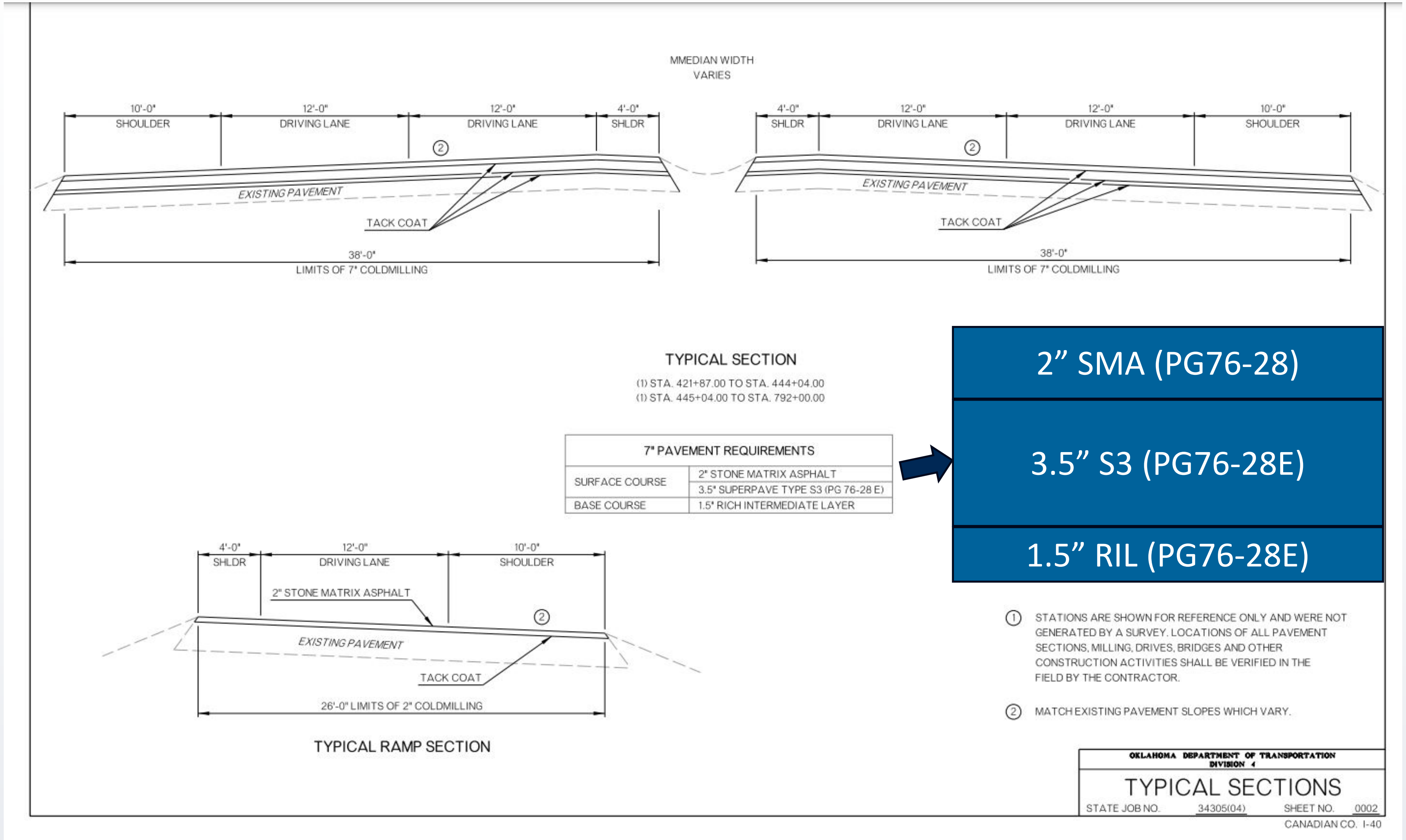
	PG76-28	PG76-28E
% $R_{3.2}$ min.	80	95
Test Temperature, °C	64	76

I-40, Caddo County

- Avg. 2021 IRI: 49.97 in/mi (EB), 47.81 in/mi (WB)*
- 2021 AADT = 29,600 with 36% trucks (7% single-unit, 29% combination)
- Recognized as a "Perpetual Pavement by Conversion" by the Asphalt Pavement Alliance

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

I-40, Canadian County, Oklahoma



2" SMA (PG76-28)

3.5" S3 (PG76-28E)

1.5" RIL (PG76-28E)

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“Rich Intermediate Layer” (RIL), ODOT Section 411(j)

- Purpose: to resist reflection of underlying cracks through the surface while providing additional pavement structure and a leveling/profiling opportunity
- Characteristics: Flexible, impermeable, provides structural benefit
- Small nominal maximum aggregate size, high binder content, low air voids mixture using <u>highly modified asphalt</u> binder

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
  - Typically, $R_{3.2} \geq 90\%$, $J_{nr3.2} \leq 0.1\ kPa^{-1}$ @ 76˚C
- Results in higher SBC content (2X-3X) that of conventional polymer-modified binder grades, but handled at similar temperatures to conventional modified binder grades (PG76-22, PG64E-22)
- Enables the use of high binder content without instability or bleeding

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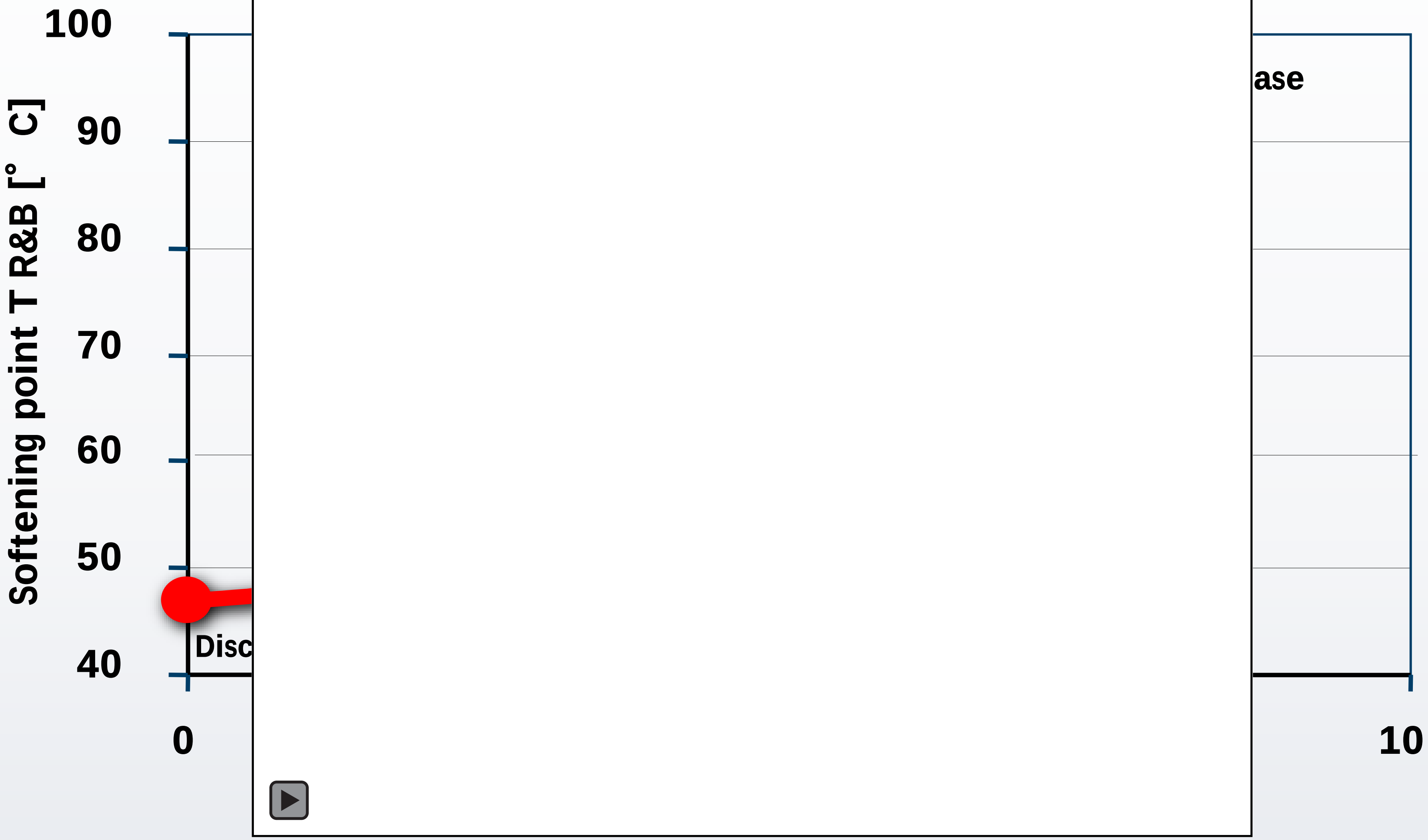
“S-Curve” – E t



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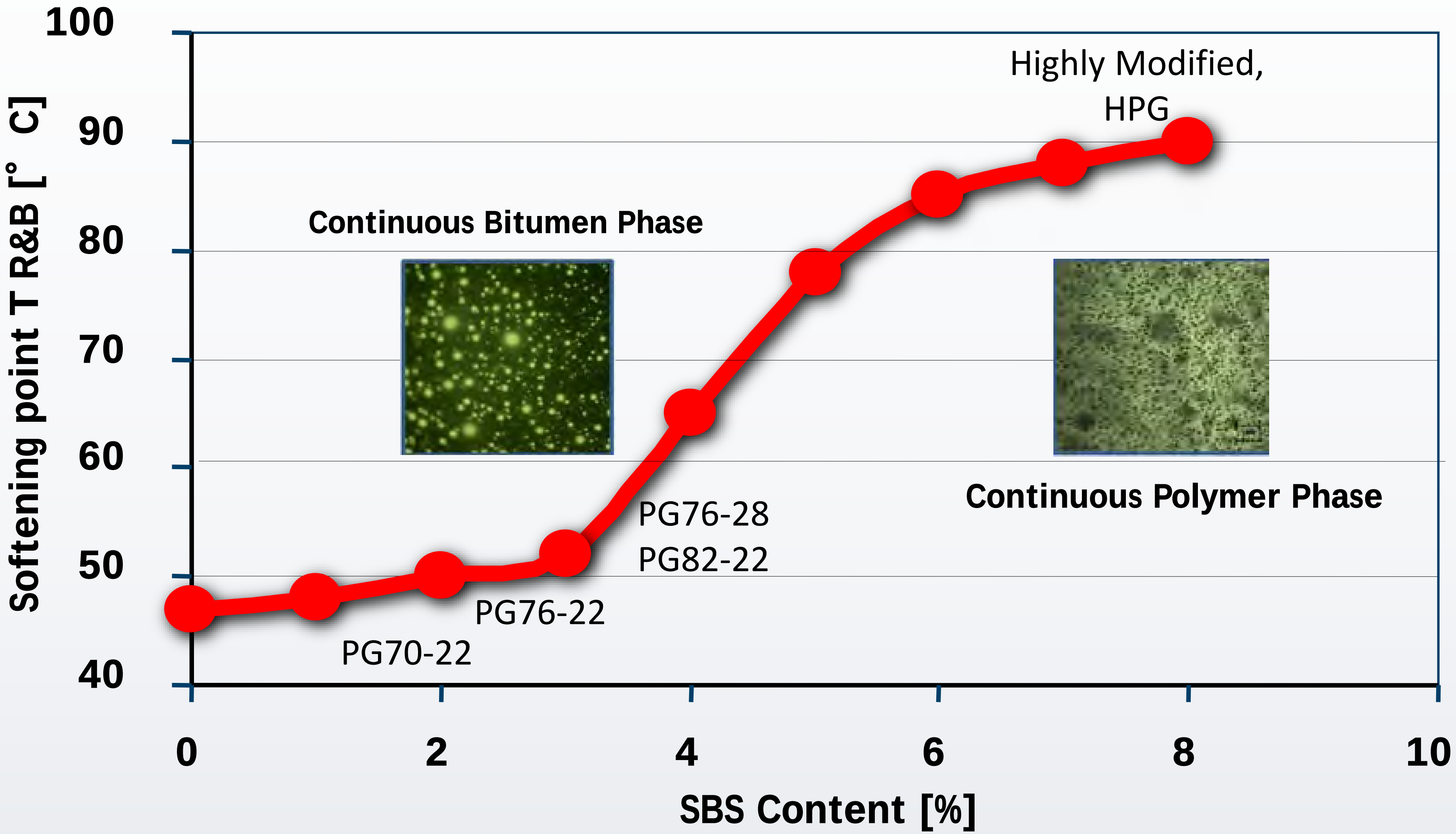
“S-Curve” – Effect of increasing SBS content



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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.

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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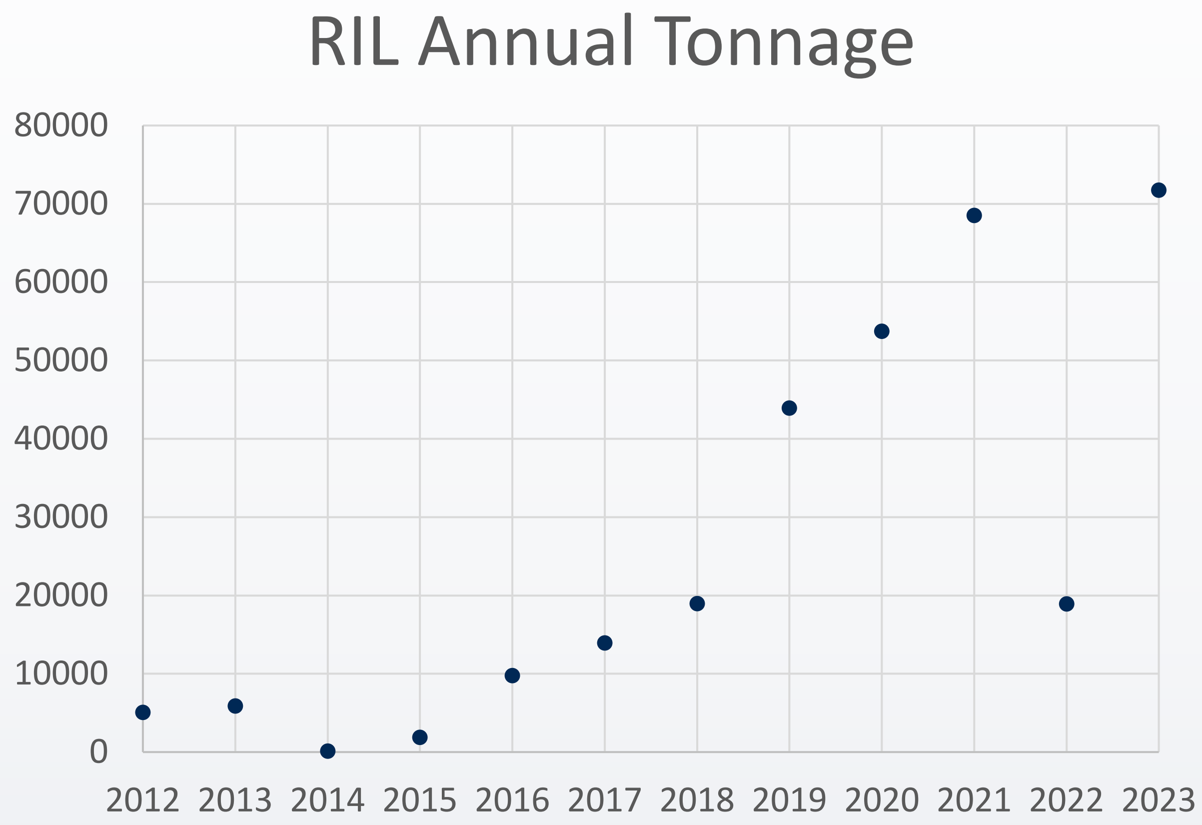
ODOT History of RIL Use: 2012-2023

- Used in all ODOT Districts
  - Most in District 1 (Muskogee, eastern Oklahoma)
- Projects ranging from county roads to Interstate highways



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Oklahoma DOT Historical Cost Data

- Oklahoma Department of Transportation publishes "Average Price History," available online
- Summarizes average unit low bid and average of three lowest bid prices for ODOT pay items

https://www.odot.org/contracts/avgprices/index.php

Oklahoma Department of Transportation
Item Price History from January 01, 2022 to June 30, 2023

July 13, 2023

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(I)2000 / SUPERPAVE, TYPE S4(PATCH)(PG64-22OK) / TON							
	01	2022Q1	2	908.00	$ 102,480.00	$ 112.86	$ 114.87
		2023Q1	1	19.00	$ 5,282.19	$ 278.01	$ 278.01
	04	2023Q1	1	150.00	$ 45,000.00	$ 300.00	$ 264.86
	05	2022Q1	1	25.00	$ 4,125.00	$ 165.00	$ 296.60
	06	2022Q1	6	1,025.70	$ 195,231.03	$ 190.34	$ 200.95
		2022Q2	1	300.00	$ 69,000.00	$ 230.00	$ 230.25
		2022Q4	3	19.20	$ 6,365.00	$ 331.51	$ 331.51
		2023Q1	2	350.00	$ 84,000.00	$ 240.00	$ 240.00
	07	2022Q1	1	225.00	$ 50,625.00	$ 225.00	$ 175.83
		2022Q2	1	200.00	$ 62,000.00	$ 310.00	$ 264.80
		2023Q2	1	225.00	$ 47,250.00	$ 210.00	$ 281.16
	08	2022Q1	4	874.00	$ 90,620.00	$ 103.68	$ 122.06
		2022Q2	1	500.00	$ 25,000.00	$ 50.00	$ 156.00
		2023Q1	1	200.00	$ 38,000.00	$ 190.00	$ 164.38
		2023Q2	2	200.00	$ 58,142.00	$ 290.71	$ 273.31
			28	5,220.90	$ 883,120.22	$ 169.15	$ 182.72
411(J)2100 / (SP) RICH INTERMEDIATE LAYER / TON							
	01	2022Q1	1	7,970.00	$ 1,170,793.00	$ 146.90	$ 150.08
		2022Q2	2	18,430.00	$ 2,913,387.50	$ 158.08	$ 158.78
		2022Q3	1	3,469.00	$ 693,800.00	$ 200.00	$ 210.47
		2022Q4	1	9,073.00	$ 1,539,688.10	$ 169.70	$ 164.85
		2023Q1	3	18,646.00	$ 3,314,101.00	$ 177.74	$ 180.71
		2023Q2	1	1,081.00	$ 187,564.31	$ 173.51	$ 168.34
	02	2022Q1	1	15,500.00	$ 1,922,000.00	$ 124.00	$ 117.00
	04	2023Q1	1	28,670.00	$ 4,228,825.00	$ 147.50	$ 147.50
	05	2022Q4	1	6,888.00	$ 1,141,479.36	$ 165.72	$ 165.72
		2023Q2	2	11,377.00	$ 1,328,150.20	$ 116.74	$ 145.89
	07	2023Q2	1	12,000.00	$ 1,677,240.00	$ 139.77	$ 169.89
			15	133,104.00	$ 20,117,028.47	$ 151.14	$ 158.21
411(L)2350 / BMD, TYPE BX(PG 70-28) / TON							
	03	2022Q1	1	1,806.37	$ 205,926.18	$ 114.00	$ 127.00
			1	1,806.37	$ 205,926.18	$ 114.00	$ 127.00
411(L)2360 / BMD, TYPE S5(PG 70-28) / TON							
		2022Q1	1	1,806.37	$ 213,151.66	$ 118.00	$ 128.00
			1	1,806.37	$ 213,151.66	$ 118.00	$ 128.00
411(M)2510 / 22" ASPHALT SPEED HUMP / EA							
	08	2023Q1	1	2.00	$ 8,000.00	$ 4,000.00	$ 2,992.58
			1	2.00	$ 8,000.00	$ 4,000.00	$ 2,992.58

Unit Costs

Item	Low bid	Avg. 3 low bids
S411(J), RIL	$151.14/ton	$158.21/ton
S407(D), Tack Coat (NT)	$4.12/gal	$4.34/gal
S409, Fabric	$3.29/sy	$3.30/sy
S409, Bit. Binder	$5.41/gal	$5.28/gal
S411 (D), Type S5 (PG64-22)	$119.64/ton	$122.54/ton
S411 (D), Type S5 (PG70-28)	$117.61/ton	$130.20/ton

Source: Oklahoma DOT(https://www.odot.org/contracts/avgprices/index.php)
Price History for July 13, 2023 (Jan 1, 2022 to June 30, 2023)

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Cost/yd^2 Comparison: RIL vs. Fabric + Leveling*

- RIL Cost = RIL (1.5 in) + Tack (trackless tack @ 0.085 gal/sy)
- Fabric = Fabric + Bituminous Binder (@ 0.225 gal/sy) + S5 (1.5 in)

Alternative, $/sy	Low Bid	Avg. 3 lowest
1.5 in Rich Intermediate Layer (RIL)	$12.48/sy	$13.07/sy
Fabric, 1.5 in. S5 (PG64-22)	$14.02/sy	$14.23/sy
Fabric, 1.5 in. S5 (PG70-28)	$13.85/sy	$14.84/sy

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

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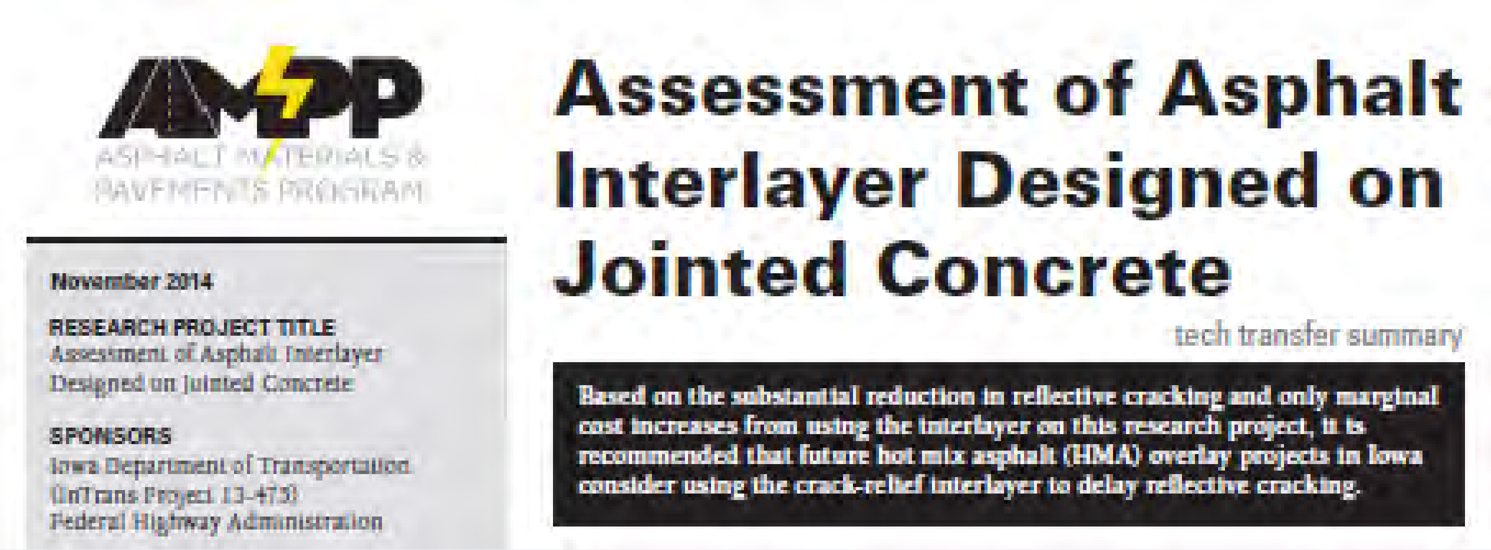
Iowa DOT Hot Mix Asphalt Interlayer Specification

- 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



AMPP
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

Iowa DOT SS-15010

Sieve Size	Mix Size – Control Points (% Passing)											
	1 inch		3/4 inch		1/2 inch		3/8 inch		HMA Interlayer		HMA Thin Lift	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
1 1/2 inch	100											
1 inch	90	100	100									
3/4 inch		90	90	100	100							
1/2 inch				90	90	100	100					
3/8 inch						90	90	100	100		91	100
No. 4								90	80	100		90
No. 8	19	45	23	49	28	58	32	67	60	85	27	63
No. 16 (1)				28		32			40	70		
No. 30 (2)				24		25			25	55		
No. 50									15	35		
No. 100									8	20		
No. 200	1	7	2	8	2	10	2	10	6	14	2	10

≈ ODOT RIL/S5 Gradation

Table 3

Performance Requirements for HMA Interlayer (2)		
Test	Requirement	Notes
AASHTO T-321	Minimum 100,000 cycles to failure	1

(1) Failure criterion at 2,000 microstrain shall be 50% of the initial flexural stress measured at the 200th load cycle.

(2) Use a PG 58-34E. (Hint: Past experience indicates at least 80%-90% recovery is needed for successful test results) Testing may be verified by the Engineer on field produced mix. Do not open to traffic until mat has cooled to below 200°F.

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

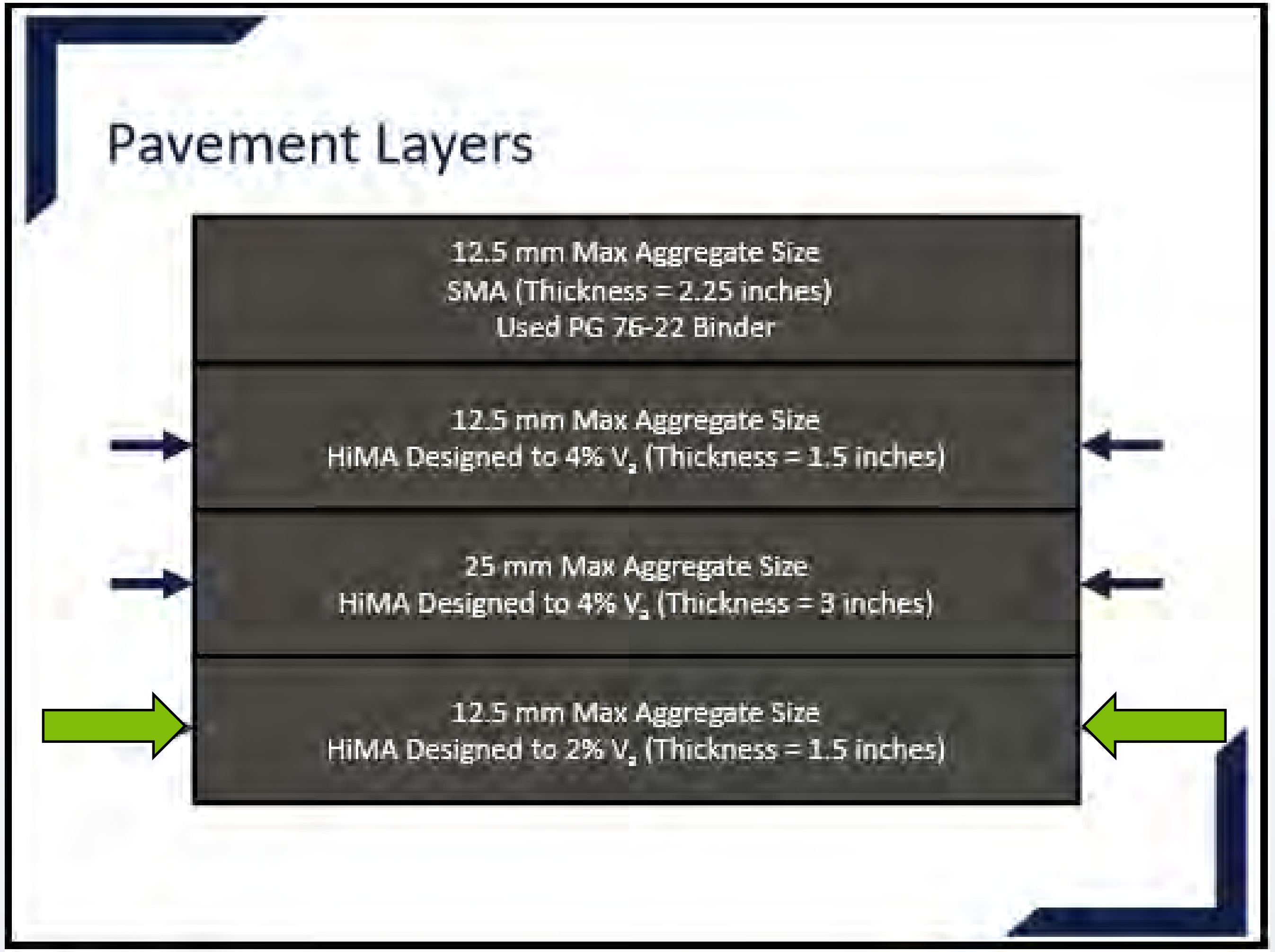
https://iowadot.gov/erl/current/IM/content/510aa.htm

Alabama DOT

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 Rehabilitation



From Braden Smith (Hunt Refining) at 2018 SEAUPG Meeting

In summary:

- RIL was a key factor in the successful rehabilitation of NCAT test section N8, sponsored by Oklahoma DOT.
- RIL was first applied in Oklahoma on I-40 in Caddo County, OK in 2012. Performance has been excellent, with no evidence of cracks reflecting from the underlying pavement.
- Since 2012, there has been increasing use of RIL in Oklahoma, and other states have/are taking similar approaches

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