JBAND™

The Bottom-Up Joint Solution

Void Reducing Asphalt Membrane Benefits at Centerline Joints

Asphalt Materials, Inc.

Presented by
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Topics to Review

- Why HMA longitudinal joints fail early
- VRAM – What is it? - A Materials Solution
- VRAM Attributes and Specification
- Performance
- Life Cycle Cost Analysis
- Safety and Sustainability

How difficult is it to find pavements like these?

Longitudinal Construction Joints

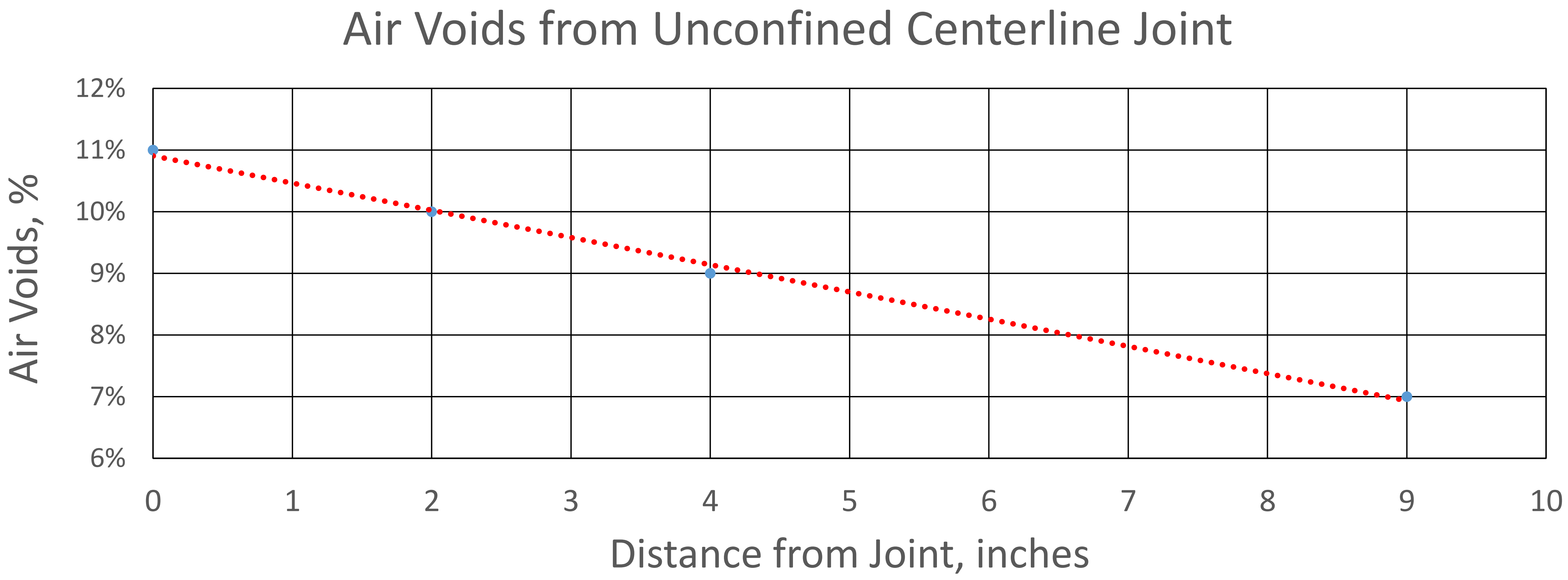
- Issues
  - Cannot achieve the same density at the joint as in the mat
  - Water and air intrusion accelerates damage
- Longitudinal construction joints
  - Commonly, the first area requiring maintenance on a pavement

Longitudinal Construction Joints

Mechanical methods to improve joint performance

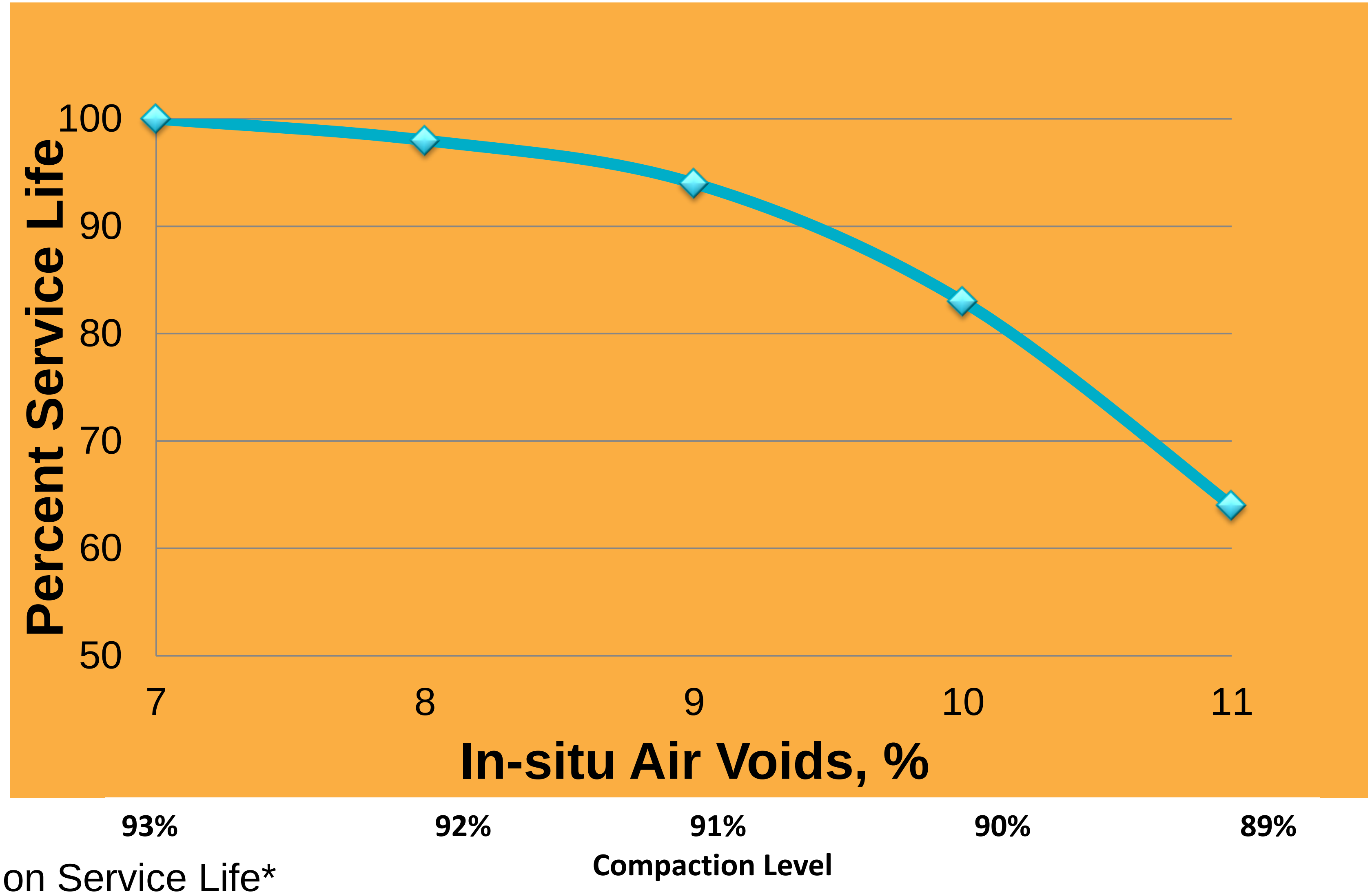
- Joint density requirements (typically target voids at 4” from joint to within 2% of center mat voids)
- Echelon paving (eliminate the joint)
- Notched wedge joint
- Cut off lower density unconfined edge
- Mill and inlay (confined)

Air Voids from Joint Towards Center of Lane



Centerline going towards interior of mat ⟶

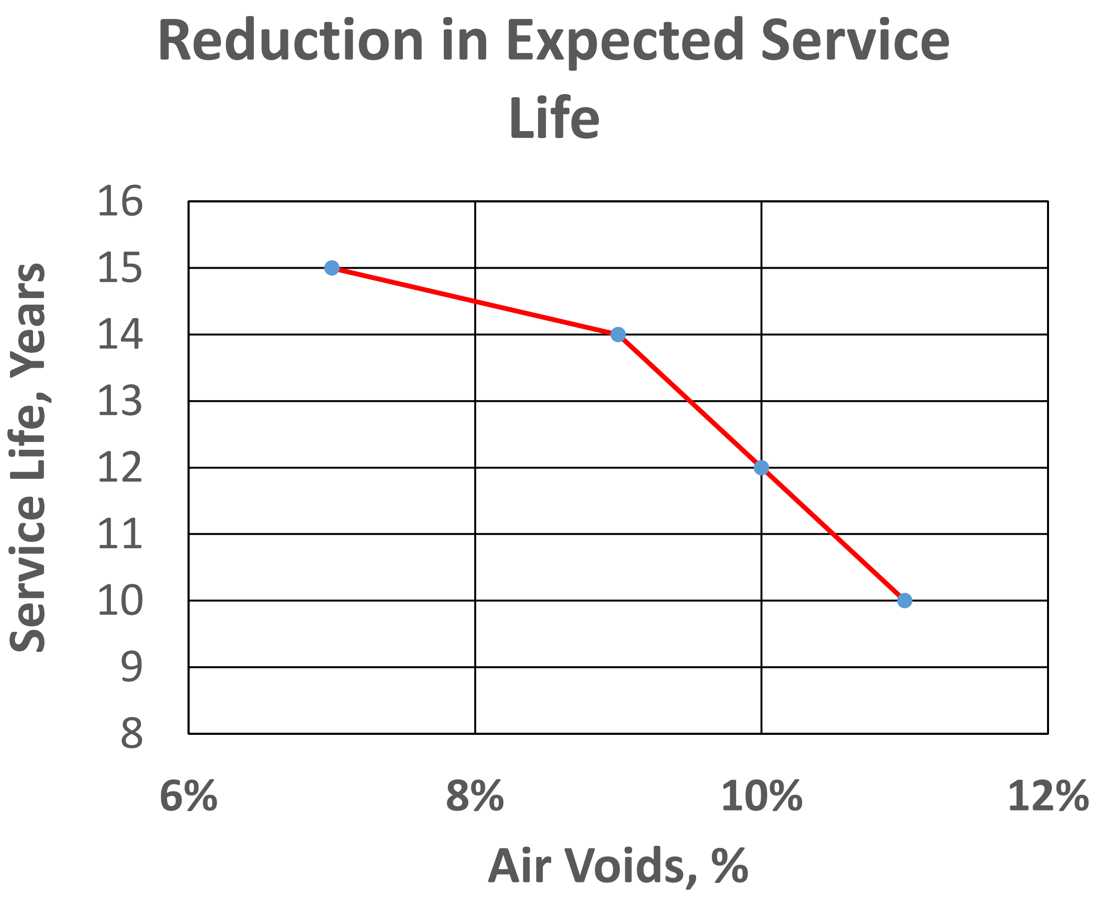
Why do joints fail early?



*Washington State DOT Study

"Effect of In-Place Voids on Service Life*

Effect of Air Voids on Pavement Service Life



If the center of the mat is at 7% voids or less, but the joint is at 11% voids, the joint fails 5 years earlier than the rest of the pavement.

A Materials Solution

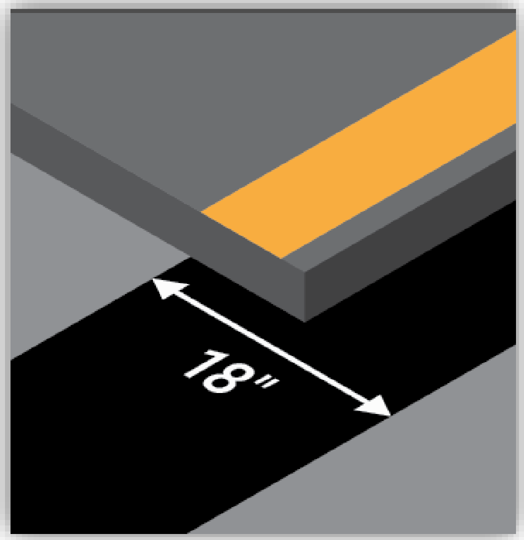
Longitudinal Joint Improvement Plan

- Early 2000 timeframe
- Illinois DOT recognized need for better joint performance
- Failure mechanism – permeability
- **Concept** – fill a portion of the voids with an asphalt product from bottom up, a Void Reducing Asphalt Membrane (VRAM)

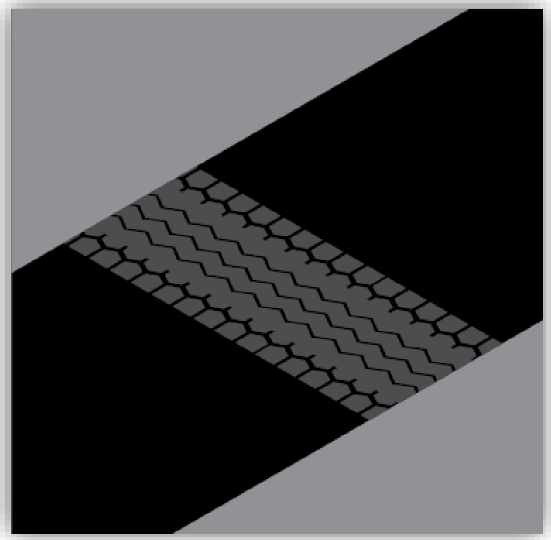
Falling head permeameter

A Different Approach to Improve Joint Performance

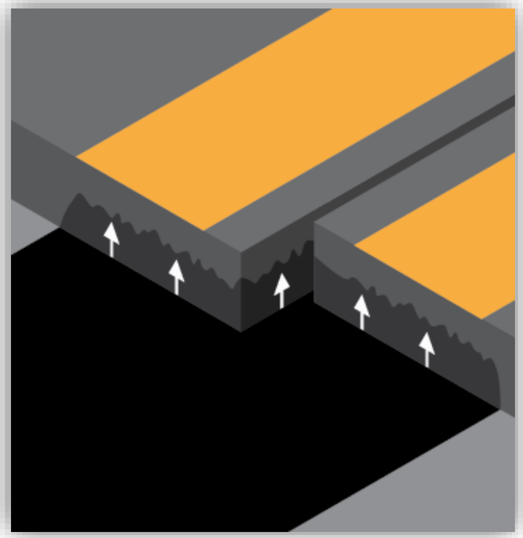
Apply a heavy band of polymer-modified binder in the area where the new paving joint will be placed.



Place the first paving pass over half the width of the band of polymer-modified binder.



Fast acting, the road is ready for construction traffic, keeping the installation process efficient and traffic flowing.



Polymer-modified binder migrates into the HMA at the joint.

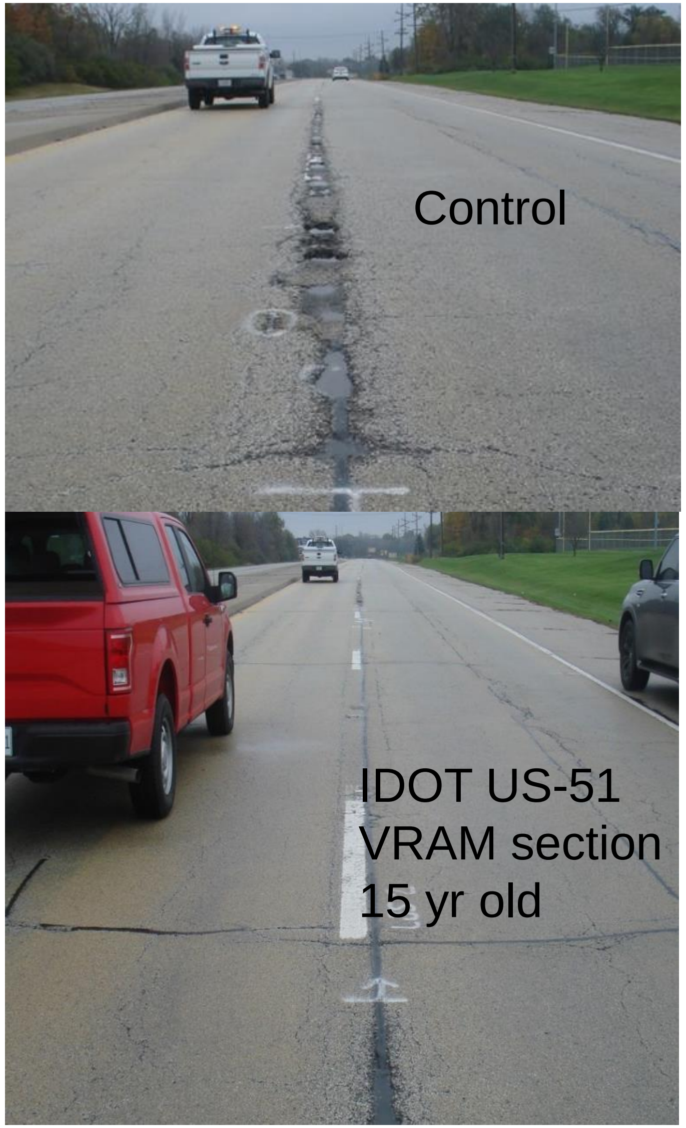
LJS Performance History

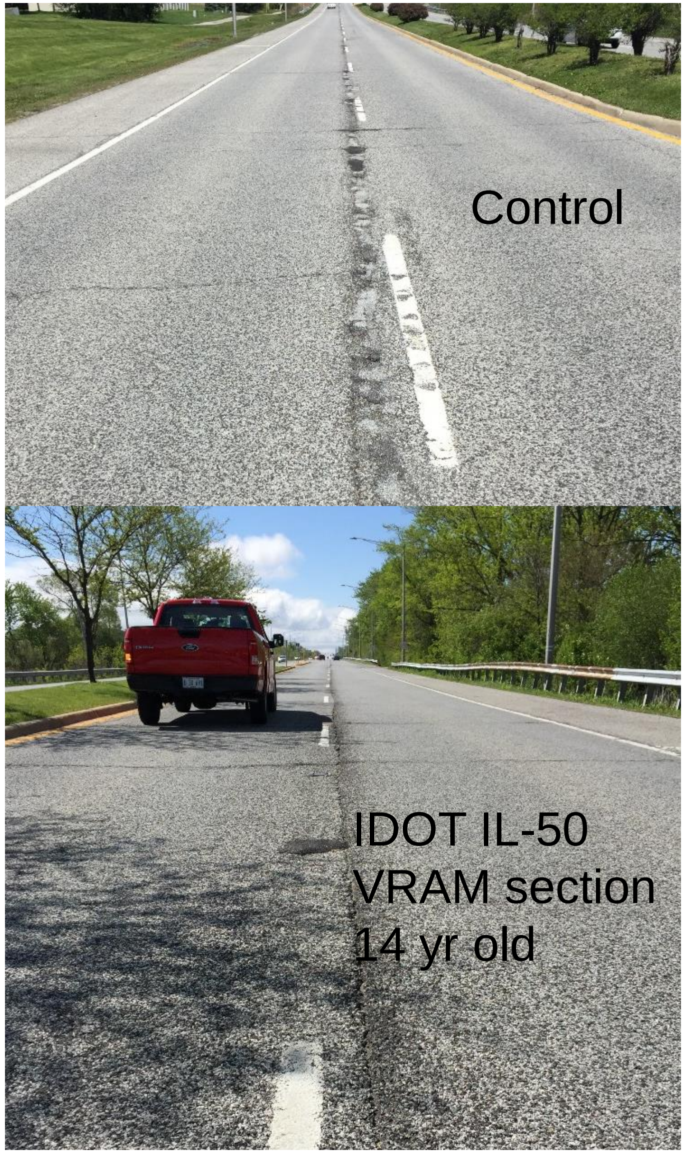
9 IDOT LJS Experimental Test Sections Placed in 2002 – 2003

Illinois DOT took cores for testing 3 of these in 2017

- District 7 US-51 Elwin
- District 1 US-50 Richton Park
- District 2 IL-26 Cedarville

VRAM Experimental Projects



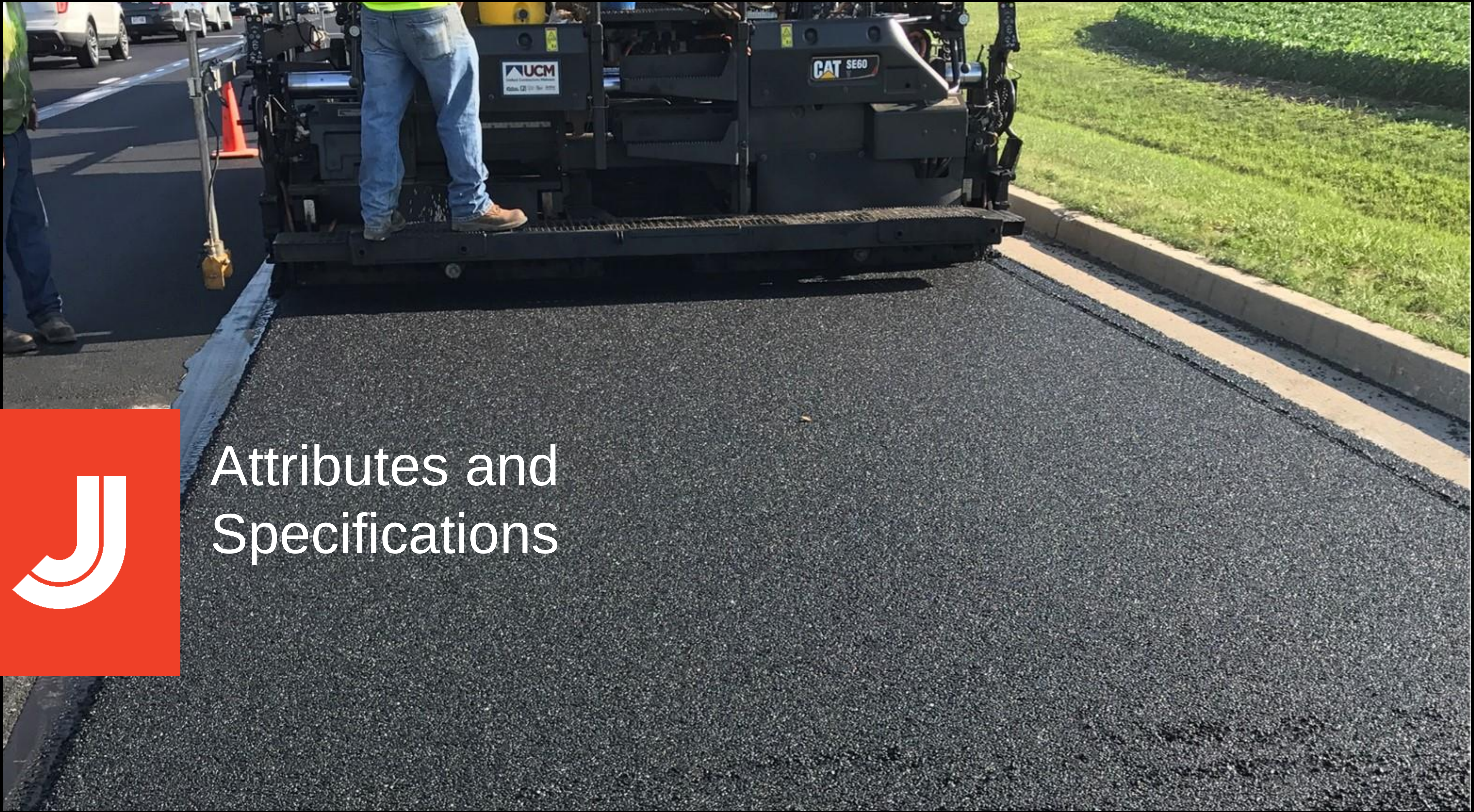


LJS Experimental Projects

IDOT US-51
LJS section
19 years old

Indianapolis Motor Speedway

- Last resurfaced in 2004 using VRAM at the joints
- Prior resurfaced every 8 to 9 years
- 2021 – No resurfacings
  - Surface seal with RPE



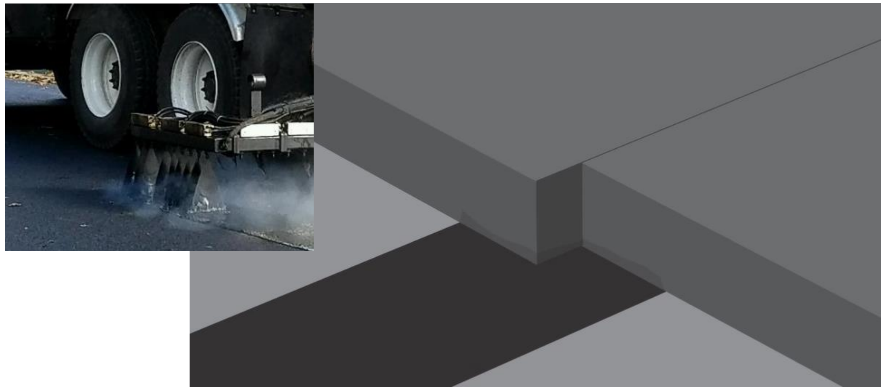
Attributes and Specifications

Void Reducing Asphalt Membrane (VRAM)

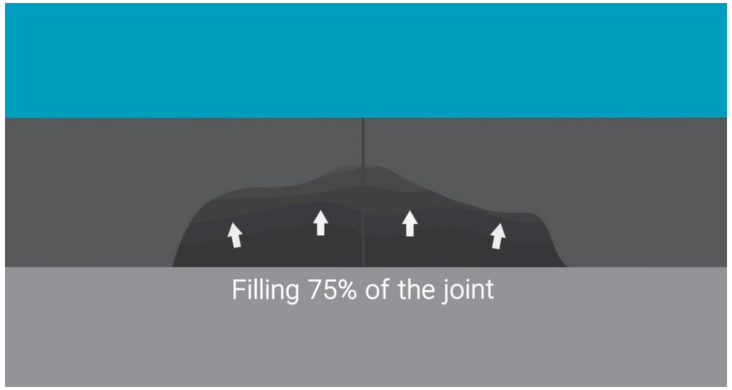
- Thick application of hot-applied, polymer-modified asphalt (~ 1 gal/sq yd for 1 ½" overlay)
- Application of an 18" band applied before paving in the location of the new longitudinal joint
- Fills voids and reduces water intrusion at joint from the bottom up
- Protects underlying pavement layers
- Materials approach to improving joint performance

BAND
The Bottom-Up Joint Solution

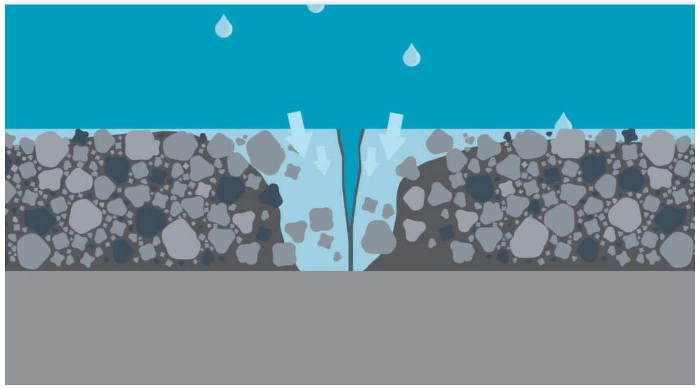
Why the increase in performance?



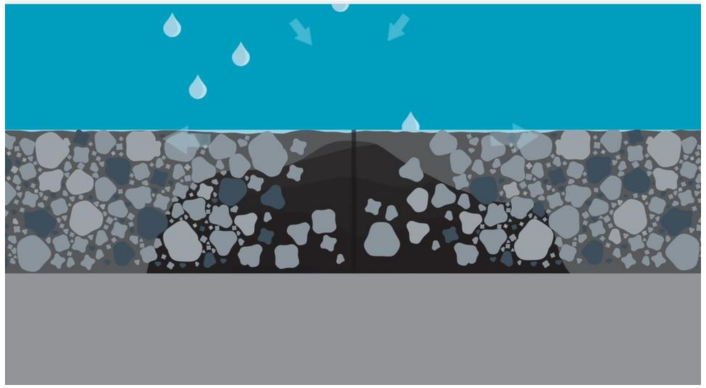
VRAM is applied, cools quickly, paved over



HMA softens VRAM, melts, filling voids in bottom part of the lift



Without VRAM in a permeable mix, water over time damages the mix

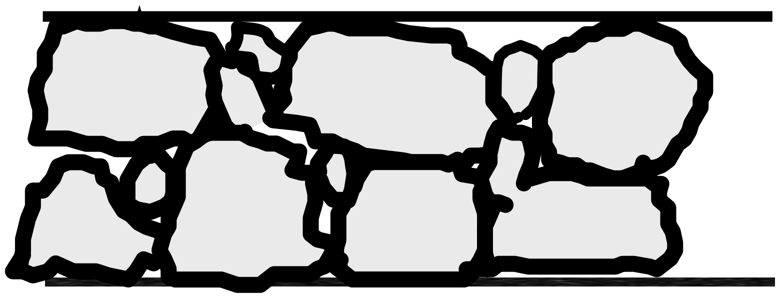


With VRAM, voids in lower portion of mix are sealed, protecting mix

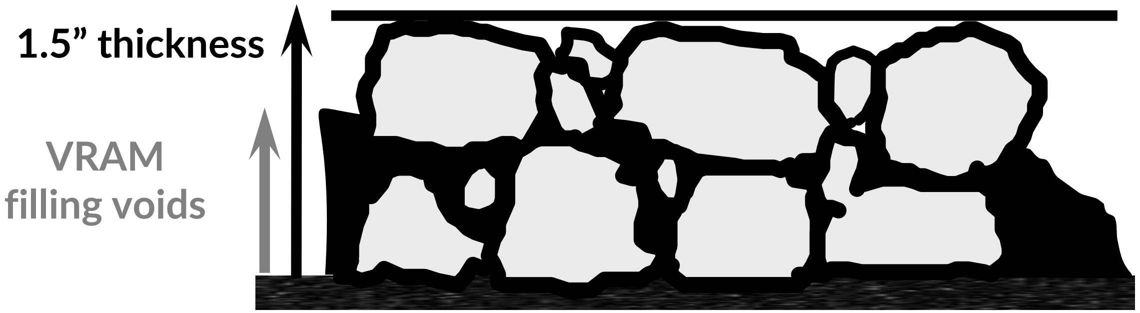
Effect of VRAM on Voids and Asphalt at Joint

Example – Coarse-graded mix

- The VRAM will migrate into the air voids with heat and compaction
- HMA @ 5.5% AC, @ 1.5” thick/square yard = 9.1 lb of AC
- VRAM @ 1.47 lb/ft – 18” equates to 8.8 lb AC/square yard
- Total AC in HMA + VRAM = 10.8%



Mix without VRAM



Mix with VRAM

Cross Sectional View at Longitudinal Joint

INDOT RSP for Void Reducing Asphalt Membrane

- 401-x-xxx for HMA and 410-x-xxx for SMA
- Top course of all category 4 9.5 mm and 12.5 mm surface courses
- Within traveled way, between traveled way and auxiliary lane, between traveled way and paved shoulder, and between auxiliary lane and paved shoulder
- Effective September 2022

INDOT VRAM Application Rate Tables

VRAM Application Rate Table			
HMA Planned Lay Rate lb/sys	VRAM Width, in.	Fine-graded HMA VRAM Application Rate, lb/ft	SMA & Coarse-graded HMA VRAM Application Rate, lb/ft
165	18	0.95	1.26
≥220	18	0.95	1.51
Tolerance		±10%	±10%

***A coarse-graded mixture shall be defined as a 9.5 mm mixture having less than 47% passing the 2.36 mm sieve or a 12.5 mm mixture having less than 39% passing the 2.36 mm sieve.*

VRAM Materials Properties

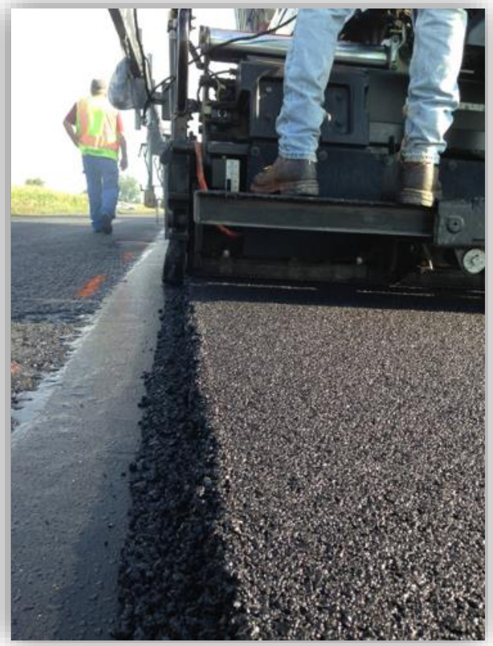
Test	Test Requirement	Test Method
Dynamic shear @ 88°C (unaged), G*/sin δ, kPa	1.00 min.	AASHTO T 315
Creep stiffness @ -18°C (unaged), Stiffness (S), MPa m-value	300 max. 0.300 min.	AASHTO T 313
Ash, %	1.0 – 4.0	AASHTO T 111
Elastic Recovery, 100 mm elongation, cut immediately, 25°C, %	70 min.	AASHTO T301
Separation of Polymer, Difference in °C of the softening point (ring and ball)	3 max.	ASTM D7173, AASHTO T53

Type A certification for the VRAM material shall be furnished in accordance with 916

VRAM Application

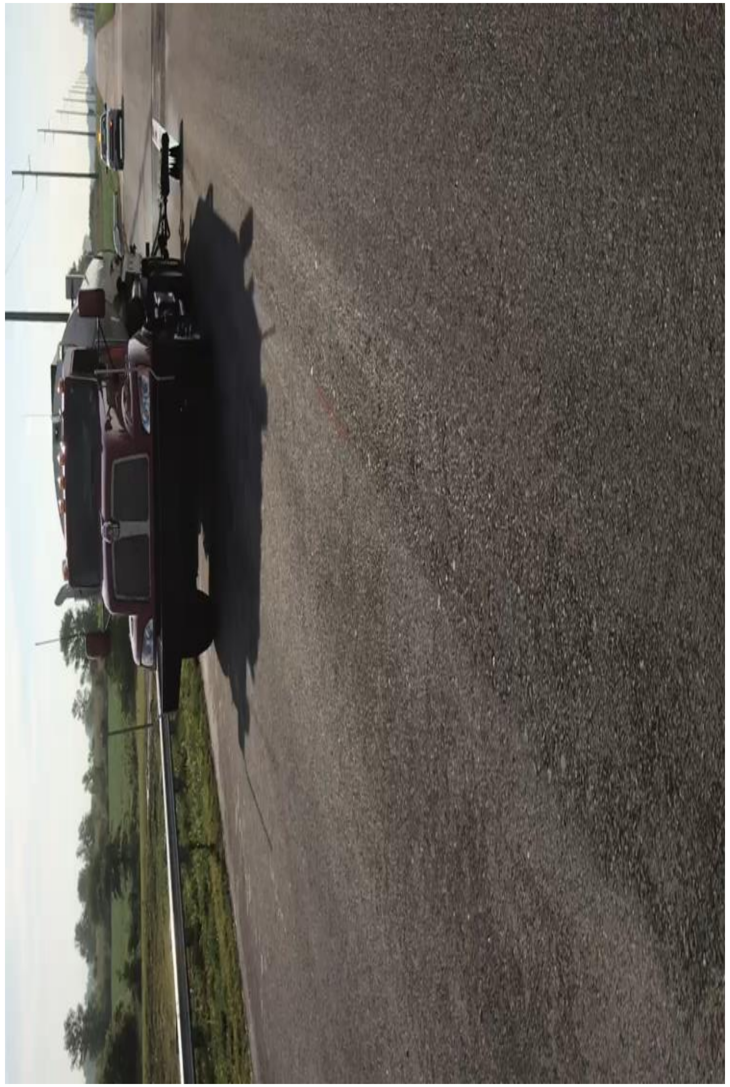
18” wide VRAM application or
9” wide mill and fill

Non-tracking < 30 min
Based on cooling time



1st pass covering
half VRAM width

VRAM Application



VRAM Performance History

9 IDOT VRAM experimental sections placed in **<u>2002 – 2003</u>**
(oldest VRAM projects)

- IDOT research reports available
- Example - IL 50 Richton Park

VRAM

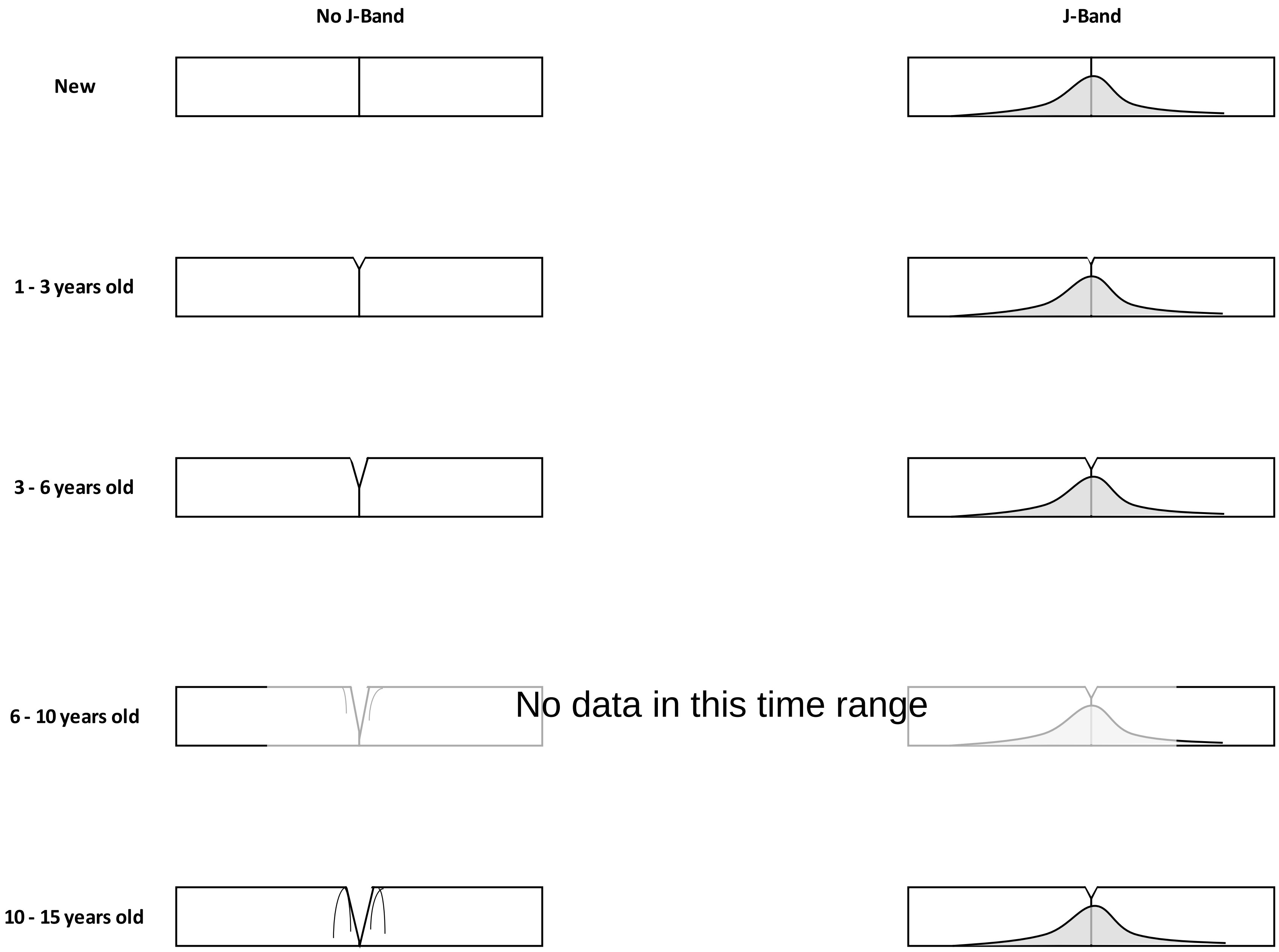
Control

IDOT core testing 14 years after service (2017)

- Asphalt content nearly double for VRAM cores
- Migration 26 to 66 percent of layer height – good performance regardless of migration height
- Laboratory permeability testing (vertical flow)
  - Top half of all cores had nearly equal lab perm.
  - Bottom half
    - Control: 110 to 372 x 10^{-5} cm/sec
    - VRAM: zero
- I-FIT flexibility index (FI) values
  - Controls: 0.2 to 0.8
  - VRAM: 1.9 to 23
  - IDOT long-term aged lab FI ≥ 4.0


Lower migration → higher

Crack Progression



Past project reviews – SR 26

2016 construction (1.47 lb/ft under 1.5”)

- Constructed in 2016
- Reviewed in 2021 – 5 winters
- VRAM was placed on a one-mile test section
- Less than 10% of VRAM section has surface joint opening
- Control sections have 50-75% cracking ¼”-3/8” width

VRAM

Control

Past project reviews – SR 119

2018 construction – No distresses; no problems at flushed edges

- 2.12 lb/ft at 18” under 2.5” intermediate lift (edges)
- 1.47 lb/ft at 18” under 1.5” surface (edges)

Past project reviews – I-65 Boone Co.

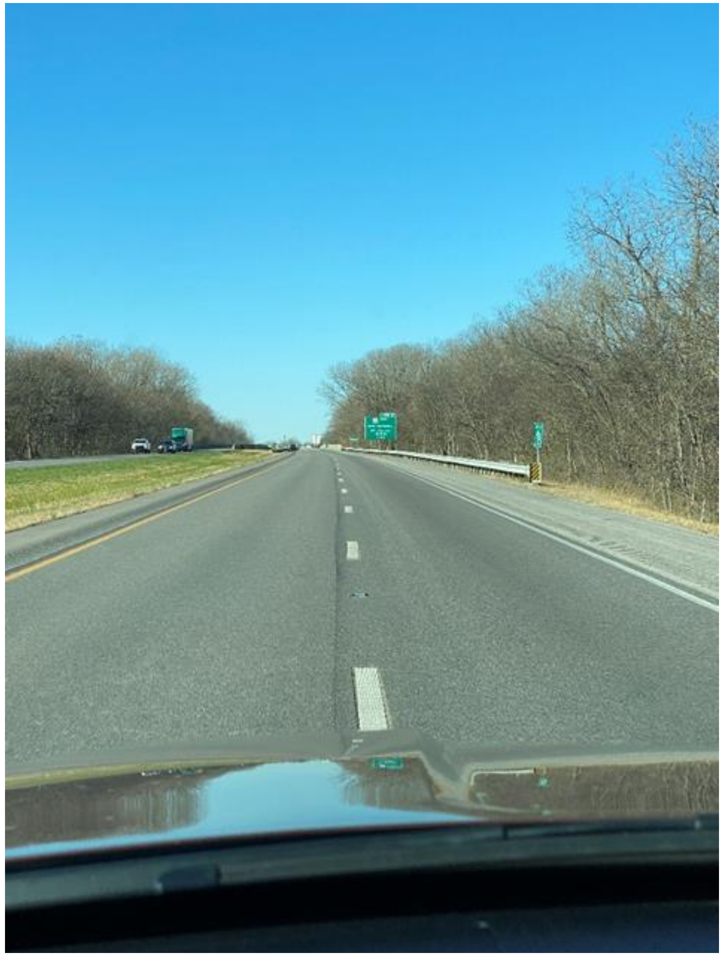
2018 construction (0.74 lb/ft under 1.5” surface, half widths)

- **Both the northbound lanes and southbound lanes are 100% cracked at centerline. Width of the crack is between ¼” to ½”. The same amount of cracking was noticed on the previous review and the cracks have not gotten any wider**

Past project reviews – I-64 Posey Co.

2019 construction

- Project looks good.
- No noticeable cracking.



Past project reviews - I-65 – Marion Co. South of 465

2019 construction

- The southbound lanes have no cracking between Lanes 1 & 2
- 80% cracking between Lanes 2& 3. The crack is 1/8” to ¼” wide.
- There is no cracking on the Northbound Lanes.
- The project looks good

Past project reviews – I-465 – Marion Co. US 31- 56th

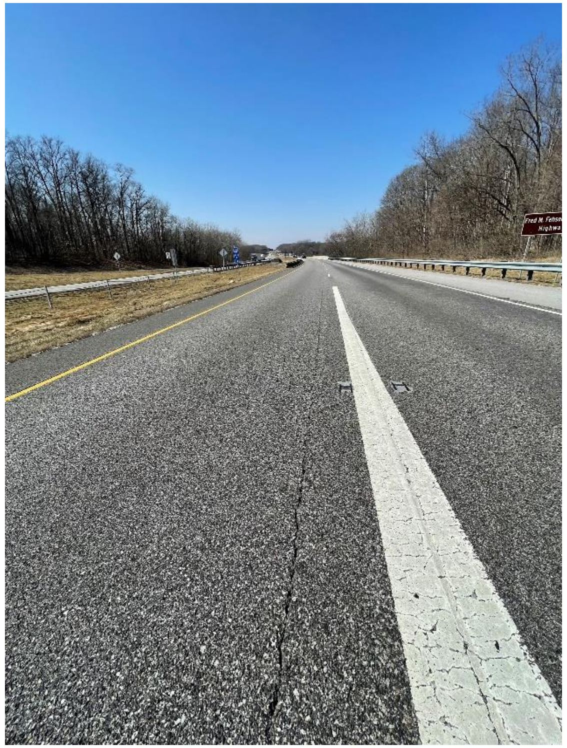
2019 construction

- Westbound:
  - Very minimal cracking in first 3 miles north of 86th Street
  - Between 86th Street and 56th Street no cracking between Lanes 1 & 2
  - ¼” at 40% cracking on others
- Eastbound Lanes:
  - 40% cracking between 56th and 86th Streets
  - 100% cracking at the 465/65 split
  - 50% cracking between Michigan Ave exit to US-31 exit.
  - Cracks are 1/8” to ¼” wide.; material loss

Past project reviews – I-865

2019 construction (1.51 lb/ft under 2” SMA)

- Reviewed in 2022 – 3 winters
- VRAM was placed on centerline and shoulder joints
- Most of the joints have surface joint opening <3/8”



VRAM Performance History

- VRAM Joint Cracking on top – 14-year-old pavement
- Example - IL 50 Richton Park

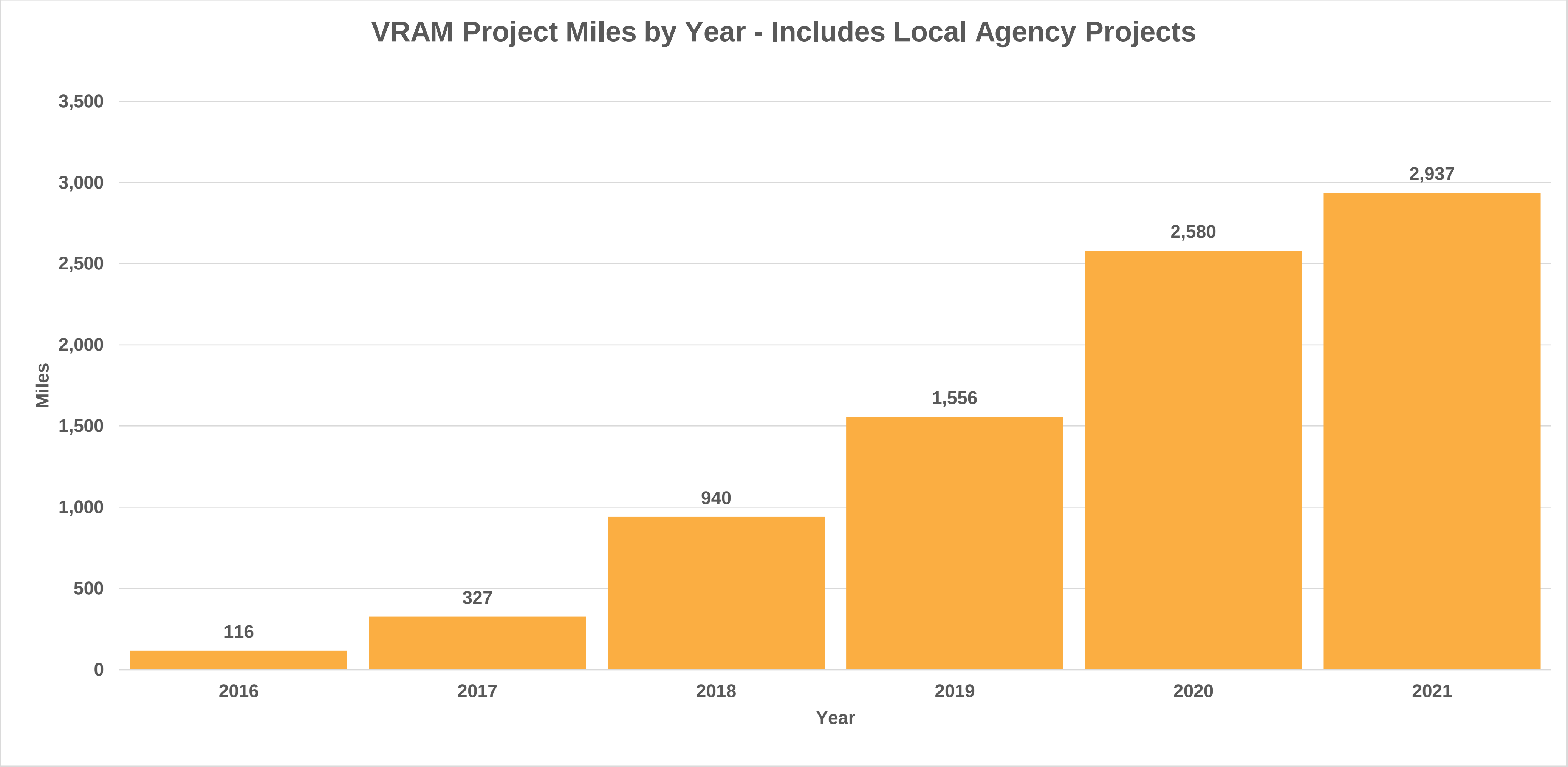
VRAM

Control

Life Cycle Cost Analysis

Growth of VRAM

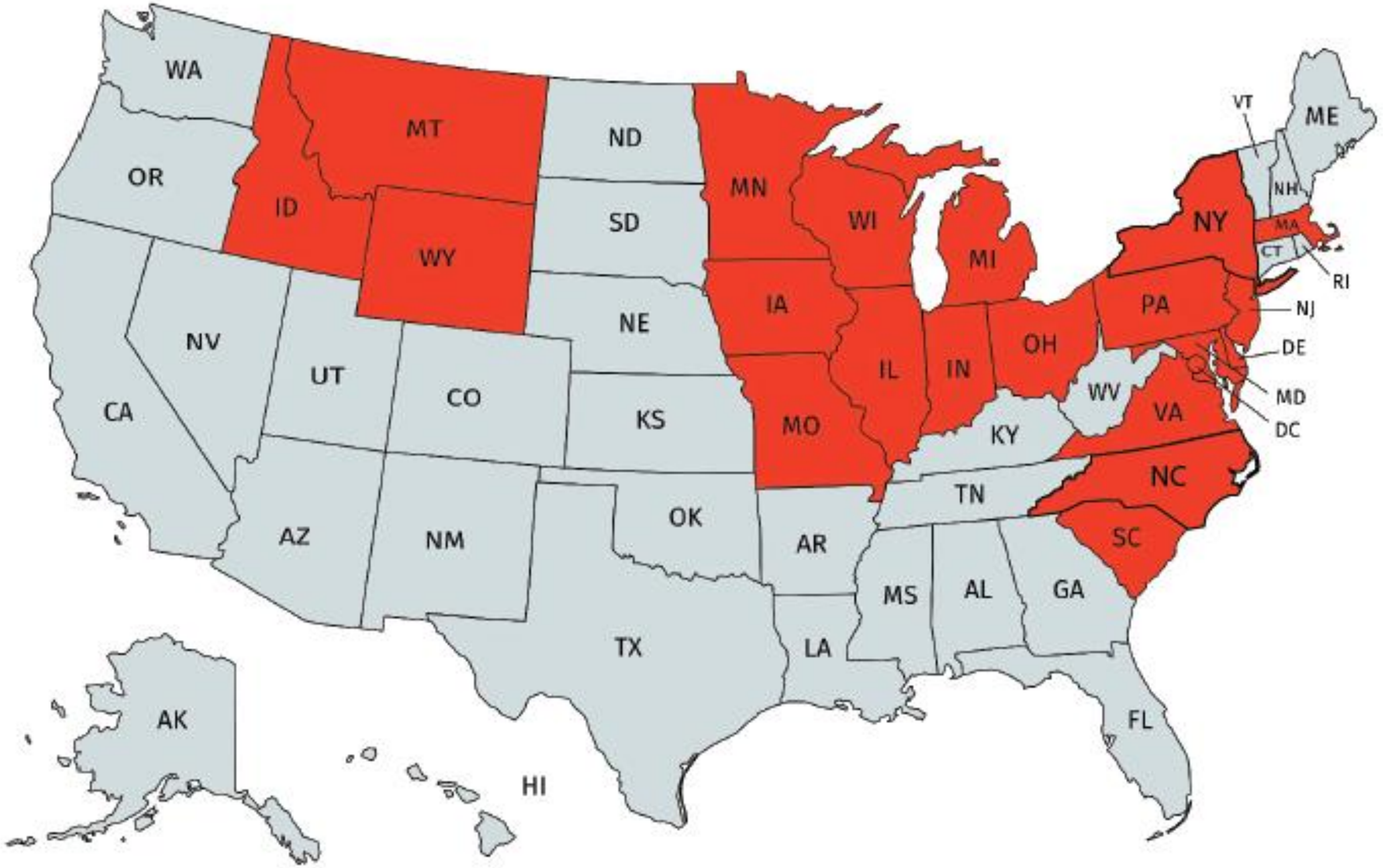
Snapshot taken mid-August 2021



Current States* with VRAM Experience

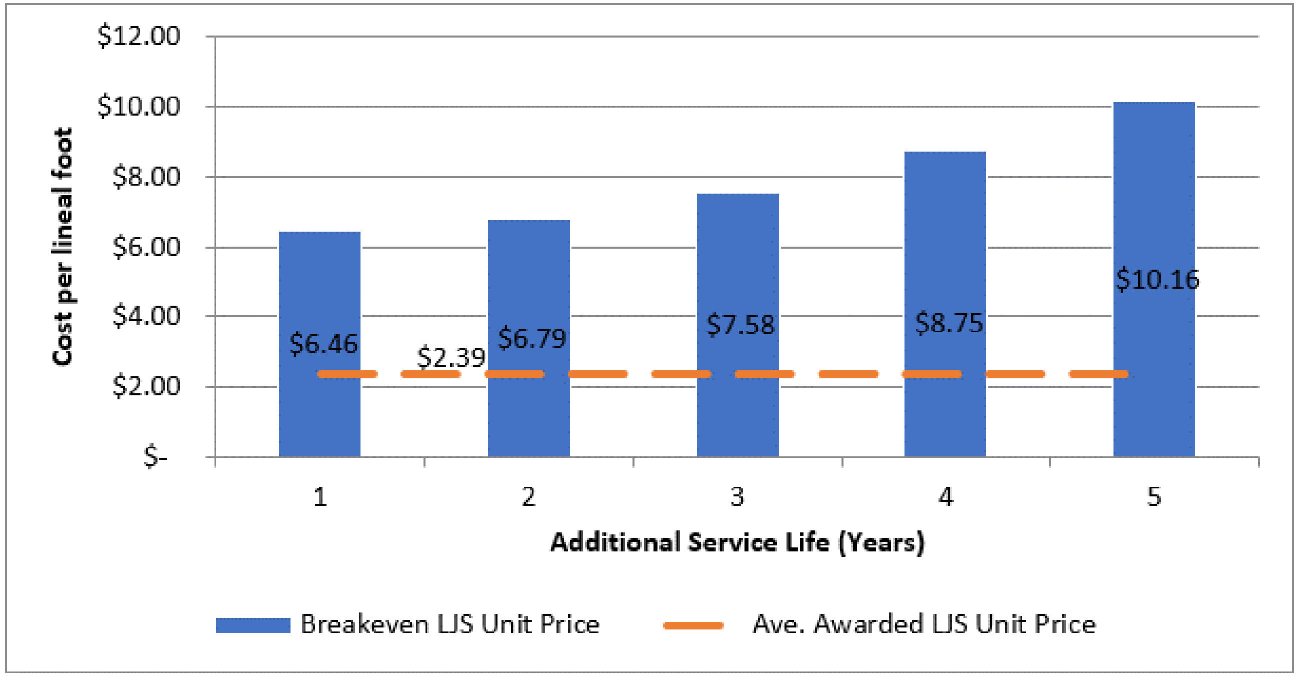
By specification, special provision, special feature, or change order

- Illinois
- Indiana
- Ohio
- Iowa
- Michigan
- Missouri
- Wisconsin
- Minnesota
- Wyoming
- Montana
- Idaho
- New Jersey
- Pennsylvania
- Massachusetts
- Maryland
- Virginia
- Delaware
- South Carolina
- District of Columbia
- New York
- North Carolina
- West Virginia



*and District of Columbia

Illinois DOT VRAM Life Cycle Cost Analysis (2 lane roadway – 15 Year basis)



- In this slide, Year 1 of ASL equals Year 16 of Pavement Life
- IDOT expects a life extension with the use of VRAM of 3 to 5 years
- The benefit of this construction practice is three to five times the cost of the material per IDOT – Source 2021 TRB Paper

INDOT
First Maintenance Cycle (20 Year basis)
Traditional Method – 2.2 Mile Project

HMA Present Worth (PW) for Initial Construction and Future Rehabilitation Work			
Age in Years	Rehabilitation Work	Cost	Present Worth Cost
0	**Initial Construction Cost**	**$8,169,679.10**	**$8,169,679.10**
3	**Joint Seal (Age 3)**	**$10,182.90**	**$9,052.56**
6	**Joint Seal (Age 6)**	**$20,365.80**	**$16,095.39**
9	**Joint Seal (Age 9)**	**$30,548.70**	**$21,463.11**
12	**Joint Seal (Age 12)**	**$40,731.60**	**$25,440.84**
15	**Joint Seal (Age > 12)**	**$40,731.60**	**$22,616.81**
18	**Joint Seal (Age > 12)**	**$40,731.60**	**$20,106.26**
20	**Mill and 2 Lifts HMA Overlay**	**$1,317,068.94**	**$601,093.07**
23	Joint Seal (Age 3)	$10,182.90	$4,131.47
26	Joint Seal (Age 6)	$20,365.80	$7,345.72
29	Joint Seal (Age 9)	$30,548.70	$9,795.48
32	Joint Seal (Age 12)	$40,731.60	$11,610.87
35	Mill and Resurface	641,443.28	$162,551.65
38	Joint Seal (Age 3)	$10,182.90	$2,294.06
41	Joint Seal (Age 6)	$20,365.80	$4,078.82
44	Mill and Resurface	$641,443.28	$114,206.63
47	Joint Seal (Age 3)	$10,182.90	$1,611.78
50	Salvage Value	$213,814.43	-$30,086.39
	Total HMA PW Cost		$9,173,087.24

INDOT First Maintenance Cycle
Traditional vs. VRAM – 20 Year basis

Inputs

Inflation Rate	0.0%
Discount Rate	4.0%
HMA Base	$61.03
HMA Binder/ Intermed	$60.70
HMA Surface	$80.19
Lane Width (Feet)	12.0
Miles Paved	1.0

* NOTE - Calculator is for a 2 lane roadway with one centerline joint
Note INDOT LCCA project is 2.2 miles long in this example.

Traditional

Treatment Number	Year of Treatment	Treatment	Cost / Mile	Future Value	Present Value
1	0	Full-Depth Pavement 13" HMA	$8,169,679	$8,169,679	$8,169,679
2	3	Joint Seal	$3,207	$3,207	$2,851
3	6	Joint Seal	$6,413	$6,413	$5,068
4	9	Joint Seal	$9,620	$9,620	$6,759
5	12	Joint Seal	$12,826	$12,826	$8,011
6	15	Joint Seal	$12,826	$12,826	$7,122
7	18	Joint Seal	$12,826	$12,826	$6,332
8	20	Major Mill & Fill (2 lifts- 4")	$1,317,069	$1,317,069	$601,093
9			$0	$0	$0
10			$0	$0	$0
11			$0	$0	$0
12			$0	$0	$0
13			$0	$0	$0
14			$0	$0	$0
15			$0	$0	$0
16			$0	$0	$0
17			$0	$0	$0
18			$0	$0	$0
19			$0	$0	$0
20			$0	$0	$0
21			$0	$0	$0
22			$0	$0	$0
23			$0	$0	$0
24			$0	$0	$0
25			$0	$0	$0
26			$0	$0	$0
27			$0	$0	$0
28			$0	$0	$0
29			$0	$0	$0
30			$0	$0	$0

J-Band

Treatment Number	Year of Treatment	Treatment	Cost / Mile	Future Value	Present Value
1	0	Full-Depth Pavement 13" HMA	$8,159,906	$8,159,906	$8,159,906
2	0	J-Band	$27,298	$27,298	$27,298
3	23	Major Mill & Fill (2 lifts- 4")	$1,317,069	$1,317,069	$534,370
4			$0	$0	$0
5			$0	$0	$0
6			$0	$0	$0
7			$0	$0	$0
8			$0	$0	$0
9			$0	$0	$0
10			$0	$0	$0
11			$0	$0	$0
12			$0	$0	$0
13			$0	$0	$0
14			$0	$0	$0
15			$0	$0	$0
16			$0	$0	$0
17			$0	$0	$0
18			$0	$0	$0
19			$0	$0	$0
20			$0	$0	$0
21			$0	$0	$0
22			$0	$0	$0
23			$0	$0	$0
24			$0	$0	$0
25			$0	$0	$0
26			$0	$0	$0
27			$0	$0	$0
28			$0	$0	$0
29			$0	$0	$0
30			$0	$0	$0

Net Present Value per Mile of Traditional Treatment	$8,806,915
Net Present Value per Mile of J-Band Treatment	$8,721,574
Savings	$85,341
Multiplied Savings as compared to J-Band intial cost	3.13

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3	6	Joint Seal	$6,413	$6,413	$5,068
4	9	Joint Seal	$9,620	$9,620	$6,759
5	12	Joint Seal	$12,826	$12,826	$8,011
6	15	Joint Seal	$12,826	$12,826	$7,12[illegible]
7	18	Joint Seal	$12,826		
8	20	Major Mill & Fill (2 lifts- 4")	$1,317,0[illegible]		
9			$0		
10			$0		
11			$0		
12			$0		
13			$0		
14			$0		
15			$0		
16			$0		
17			$0		
18			$0		
19			$0		
20			$0		
21			$0		
22			$0		
23			$0		
24			$0		
25			$0	$0	$0
26			$0	$0	$0
27			$0	$0	$0
28			$0	$0	$0
29			$0	$0	$0
30			$0	$0	$0

J-Band

Treatment Number	Year of Treatment	Treatment	Cost / Mile	Future Value	Present Value
1	0	Full-Depth Pavement 13" HMA	$8,159,906	$8,159,906	$8,159,906
2	0	J-Band	$27,298	$27,298	$27,298
3	23	Major Mill & Fill (2 lifts- 4")	$1,317,069	$1,317,069	$534,370
4			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
25			$0	$0	$0
26			$0	$0	$0
27			$0	$0	$0
28			$0	$0	$0
29			$0	$0	$0
30			$0	$0	$0

Treatment Number	Year of Treatment	Treatment	Cost / Mile	Future Value	Present Value
1	0	Full-Depth Pavement 13" HMA	$8,159,906	$8,159,906	$8,159,906
2	0	J-Band	$27,298	$27,298	$27,298
3	23	Major Mill & Fill (2 lifts- 4")	$1,317,069	$1,317,069	$534,370

Net Present Value per Mile of Traditional Treatment	$8,806,915
Net Present Value per Mile of J-Band Treatment	$8,721,574
Savings	$85,341
Multiplied Savings as compared to J-Band intial cost	3.13

INDOT First Maintenance Cycle
Traditional vs. VRAM – 20 Year basis

Inputs

Inflation Rate	0.0%
Discount Rate	4.0%
HMA Base	$61.03
HMA Binder/ Intermed	$60.70
HMA Surface	$80.19
Lane Width (Feet)	12.0
Miles Paved	1.0

* NOTE - Calculator is for a 2 lane roadway with one centerline joint
Note INDOT LCCA project is 2.2 miles long in this example.

Traditional

Treatment Number	Year of Treatment	Treatment	Cost / Mile	Future Value	Present Value
1	0	Full-Depth Pavement 13" HMA	$8,169,679	$8,169,679	$8,169,679
2	3	Joint Seal	$3,207	$3,207	$2,851
3	6	Joint Seal	$6,413	$6,413	$5,068
4	9	Joint Seal	$9,620	$9,620	$6,759
5	12	Joint Seal	$12,826	$12,826	$8,011
6	15	Joint Seal	$12,826	$12,826	$7,122
7	18	Joint Seal	$12,826	$12,826	$6,332
8	20	Major Mill & Fill (2 lifts- 4")	$1,317,069	$1,317,069	$601,093
9			$0	$0	$0
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29				$0	$0
30				$0	$0

J-Band

Treatment Number	Year of Treatment	Treatment	Cost / Mile	Future Value	Present Value
1	0	Full-Depth Pavement 13" HMA	$8,159,906	$8,159,906	$8,159,906
2	0	J-Band	$27,298	$27,298	$27,298
3	23	Major Mill & Fill (2 lifts- 4")	$1,317,069	$1,317,069	$534,370
4			$0	$0	$0
5			$0	$0	$0
6			$0	$0	$0
7			$0	$0	$0
8			$0	$0	$0
9			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
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			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
			$0	$0	$0
29			$0	$0	$0
30			$0	$0	$0

Net Present Value per Mile of Traditional Treatment	$8,806,915
Net Present Value per Mile of J-Band Treatment	$8,721,574
Savings	$85,341
Multiplied Savings as compared to J-Band intial cost	3.13

Net Present Value per Mile of Traditional Treatment **$8,806,915**
Net Present Value per Mile of J-Band Treatment **$8,721,574**
Savings **$85,341**
Multiplied Savings as compared to J-Band intial cost **3.13**

Value of a VRAM

- What if you pave 10 miles of HMA with VRAM per year as part of your Pavement Management System?
- Extend life of each mile of those overlays 3 years
- You realize an annual Life Cycle Cost savings of <u>$389,000</u> for an initial investment of <u>$125,000</u>
- Utilize those savings to improve the overall system
  - Example – would mill and pave an additional 3.6 miles of 1 ½" HMA at 24' wide. (Assumes: $80/ton HMA and $1.00/SY milling)

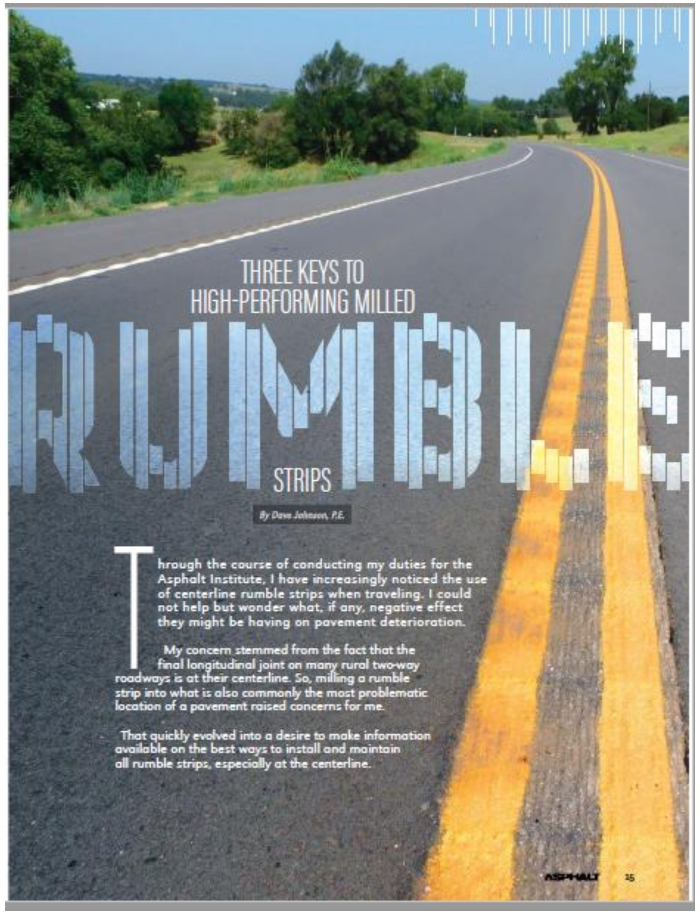
Safety and Sustainability

How much danger to do the repair?

Danger from Distracted Drivers

VRAMs as applied to Safety

- A VRAM can extend the life of the construction joint
- Avoids lane closures for maintenance and repair
- Improves <u>public safety</u> and <u>worker safety</u>
  - No need to core at CL for QC
- Protect rumble strips
- Protect paint markings & RPMs



THREE KEYS TO HIGH-PERFORMING MILLED RUMBLE STRIPS

By Dave Johnson, P.E.

Through the course of conducting my duties for the Asphalt Institute, I have increasingly noticed the use of centerline rumble strips when traveling. I could not help but wonder what, if any, negative effect they might be having on pavement deterioration.

My concern stemmed from the fact that the final longitudinal joint on many rural two-way roadways is at their centerline. So, milling a rumble strip into what is also commonly the most problematic location of a pavement raised concerns for me.

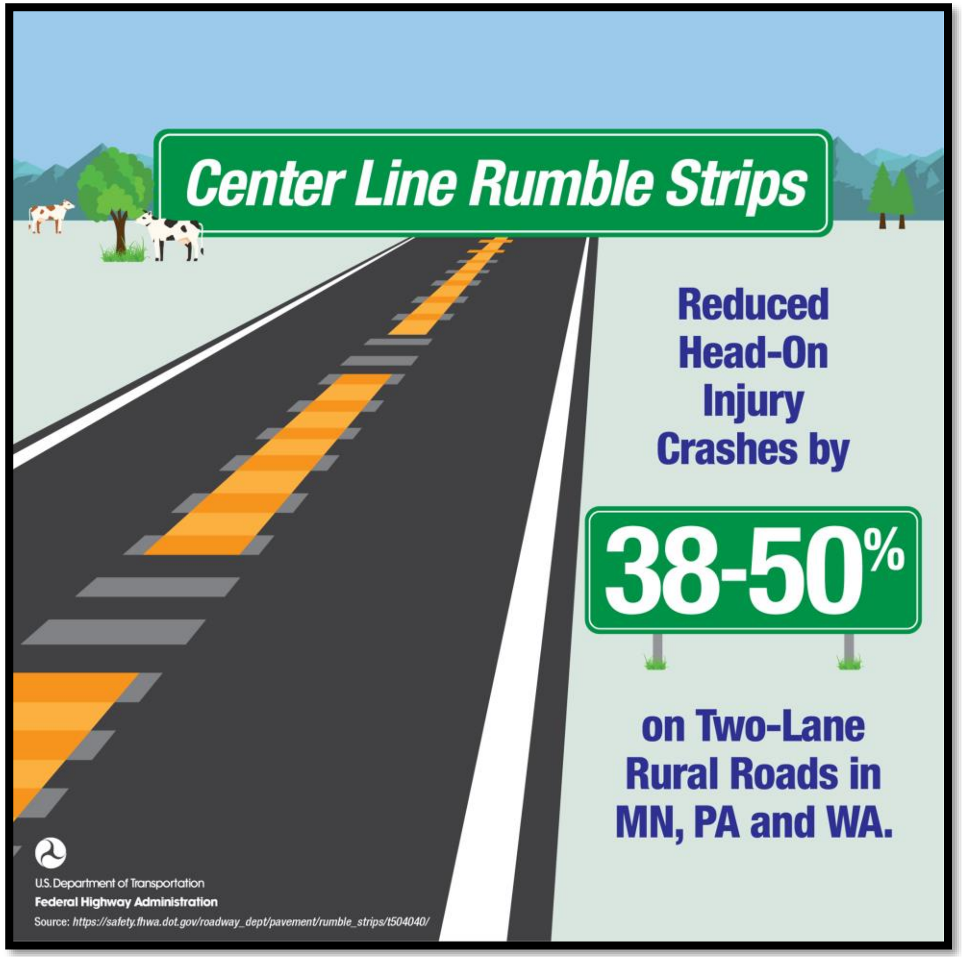
That quickly evolved into a desire to make information available on the best ways to install and maintain all rumble strips, especially at the centerline.

ASPHALT 15

Rumble Strips Can Help Save Lives

In 2019:

7,389	Crashes in left of center accidents in Ohio
160	Fatalities in left of center accidents in Ohio
16,261	Roadway departure fatalities nationally

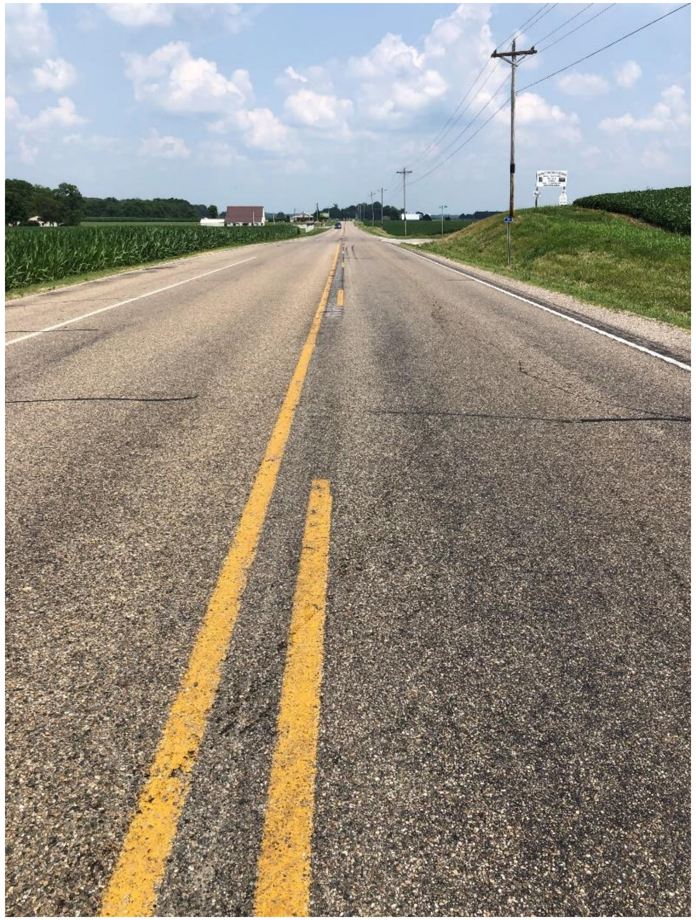


VRAM Under Rumble Strips

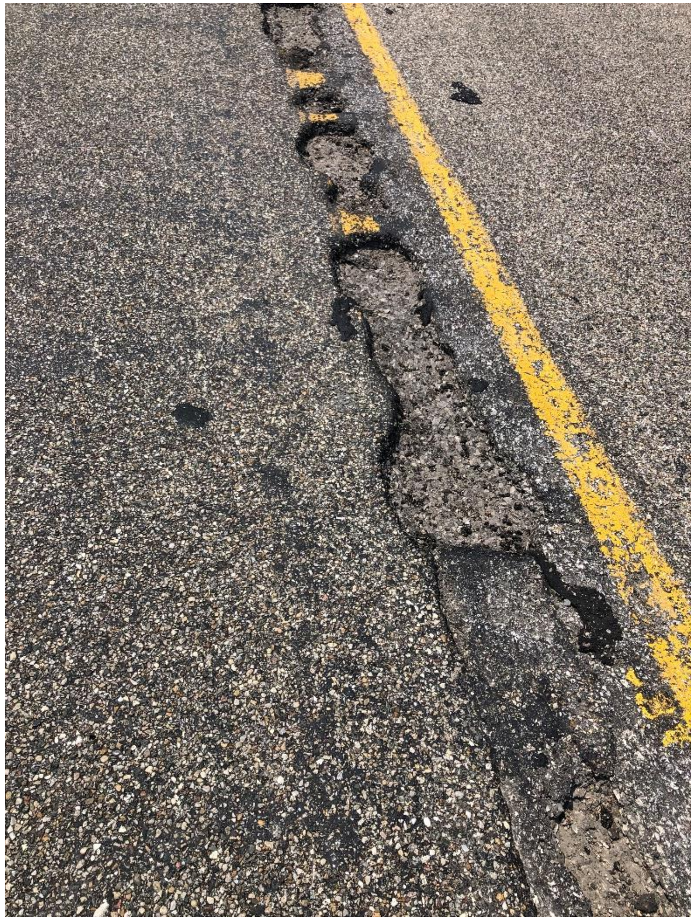
- Rumble strips/corrugations
  - being used on an increasing basis for safety
  - placed in the weakest area of the pavement, centerline joint or outside edge of paving creating early failure
- VRAM under centerline or edge rumble strips to reduce air/water permeability
- Sealed after milled in to reduce water penetration

Rumble strips on IN highways

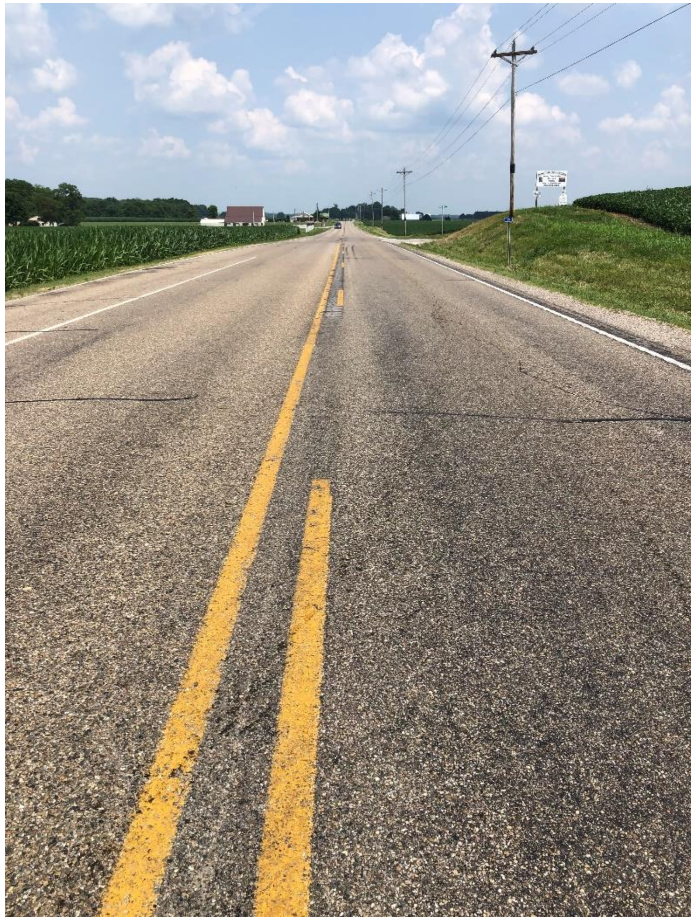
- US-36 west of Indy
- Intersection with no rumble strips vs. rumble strips in rest of road

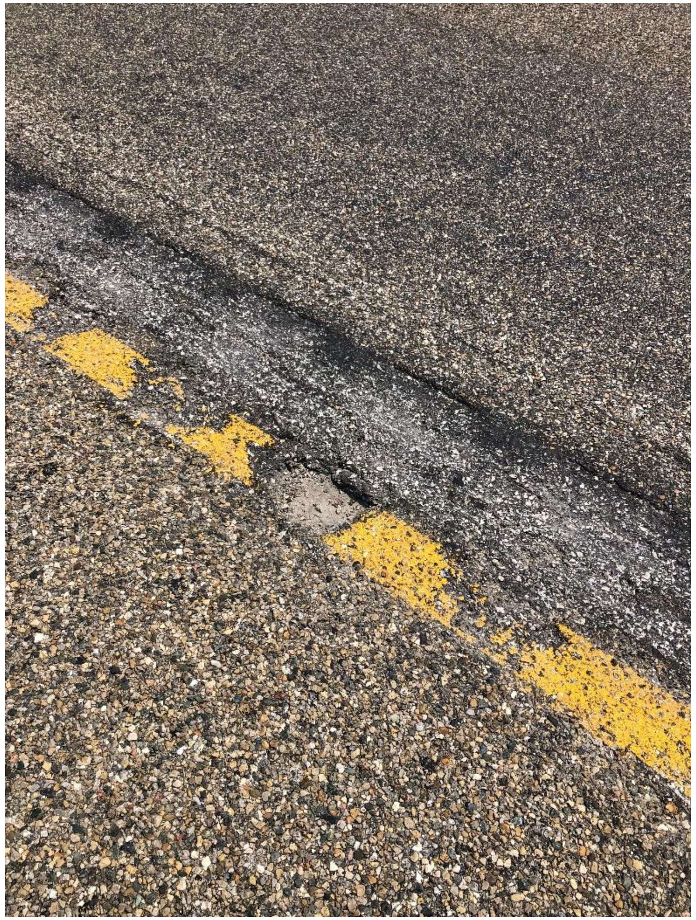


11345 E US-36, Rockville



CR 880W intersection





Parke County US-36 rumble strips

- Chip seal looks like it was placed after rumble strips and doesn’t appear to help
- Deterioration stops at underlying layer, indicating delamination or stripping
- Intersection (no rumble strips) in good condition, but surrounding RSs starting to show distress
- It appears the rumble strips accelerated the damage of the CL joint

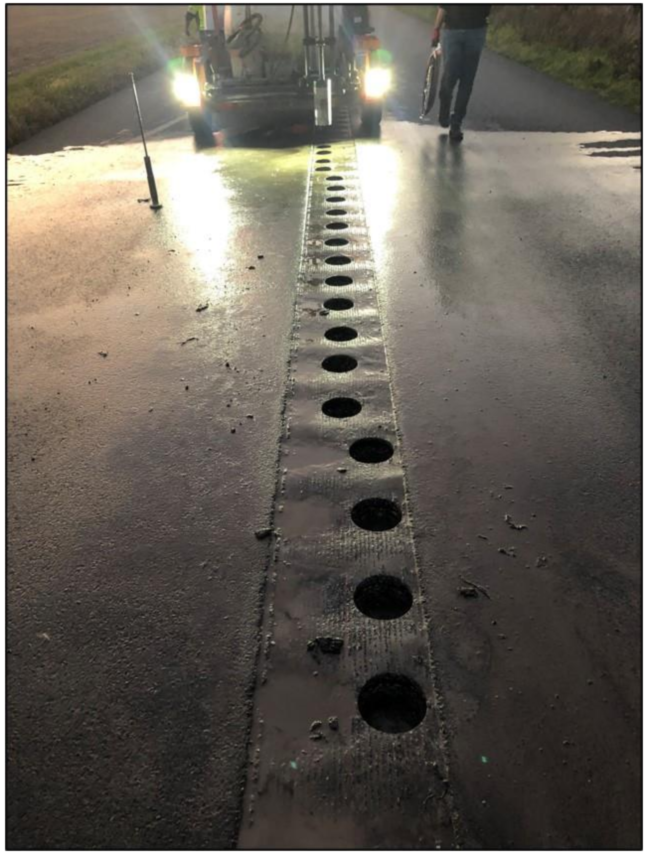
SR-26

Constructed – 2016 Reviewed - 2020

VRAM

Non-VRAM - Control

VRAM Under Rumble Strips



- Research by Asphalt Materials Inc. / Heritage Research Group built a small section in 2021
- Extensive lab testing underway
- Initial findings – Air voids increase ~4% with the grinding of rumble strips

VRAM Under Rumble Strips

- VRAM under centerline or edge rumble strips to reduce air/water permeability
- VRAM creates a binder rich interlayer that creates a strong bond of the surface to the subsurface.
- Modifies the mix and makes it more durable

J-Band as applied to Sustainability

- AMI partnered with ClimeCo to study sustainability of J-Band VRAM
- ClimeCo is a sustainability, climate change, and environmental commodities firm
- AMI wanted to build on J-Band VRAM pavement life-extension to understand its sustainability benefits

ClimeCo

NEWS RELEASE
FOR IMMEDIATE DISTRIBUTION
CONTACT
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NCAA Championship Basketball Carbon Neutral in 2021

by Nancy Marshall | Aug 17, 2021

August 17, 2021 (Boyertown, PA) – ClimeCo is pleased to be a part of the effort to make the NCAA Division I Men's Basketball Championship carbon neutral. ClimeCo teamed up with Heritage Interactive Services (Heritage) to contribute offsets to mitigate this year's tournament, held in Indianapolis, IN.

IUPUI's Office of Sustainability, a partnership between Indiana University and Perdue University, collected emissions data across seven event venues, including electricity, gas, steam, and chilled water. This data was used to quantify the greenhouse gas footprint and determine the number of carbon offsets necessary to achieve carbon neutrality for March Madness.

Sustainability

Greenhouse Gas

	GHG Emissions (kgCO2e)			
	JBand	Joint Adhesive	IR Heater	PWTB
Manufacture	458.6	35.6	-	3,042.4
Transport	136.3	160.0	-	58.1
Application	2.7	119.5	400.0	1,834.1
Maintenance trips	274.7	444.2	444.2	444.2
Total over lifetime	**872.3**	**759.3**	**844.2**	**5,378.8**
Averaged per year emissions	**48.5**	**50.6**	**52.8**	**358.6**

*Greenhouse Gas Emissions, in kilograms of CO2 equivalents, broken down by segments of the construction process. This is for a 1-mile project distance, 50 miles away from manufacturing site**

**Distance only applies to J-Band and Joint Adhesive. Distance between the home base and project site for IR heater and PWTB is assumed to be 30 miles.*

Sustainability

ClimeCo

Air Quality

	Lb Pollutant (VOC/CO/NOx/PM2.5)			
	JBand	Joint Adhesive	IR Heater	PWTB
Manufacture	0.00072	0.00004	-	12.60
Transport	1.8	3.7	-	1.6
Application	0.061	1.5	1.5	122.7
Maintenance trips	1.8	26.7	26.7	26.7
Total over lifetime	**3.7**	**31.8**	**28.2**	**163.6**
Averaged per year emissions	**0.2**	**2.1**	**1.8**	**10.9**

*Pounds of pollutants emitted during all phases (manufacture through maintenance) for a 1-mile project distance, 50 miles away from manufacturing site**

**Distance only applies to J-Band and Joint Adhesive. Distance between the home base and project site for IR heater and PWTB is assumed to be 30 miles.*

Sustainability

Safety

	Injuries per million miles				Fatalities per million miles			
	JBand	Joint Adhesive	IR Heater	PWTB	JBand	Joint Adhesive	IR Heater	PWTB
Application	21	32	189	284	0.7	1.1	6.3	9.5
Maintenance Trips	44	837	837	837	1.5	28.0	28.0	28.0
Total over lifetime	**65**	**868**	**1026**	**1120**	**2.2**	**29.1**	**34.4**	**37.5**
Average per year	**4**	**58**	**64**	**75**	**0.1**	**1.9**	**2.1**	**2.5**

Number of worker safety incidents. Safety metrics have been normalized to one million miles for ease of comprehension.

VRAM Summary

- Provides a material solution to improving quality at the longitudinal joint
- Application rate based on volumetrics (tailored to specific mix types)
- Provides improved cracking resistance and durability

VRAM Summary

- Multiple projects indicate improved long-term performance and life cycle cost savings
- Reduces or eliminates the need for joint maintenance which increases safety
- Rumble strip use – longer lasting benefits
- Has sustainability benefits compared to other joint construction practices

For more information go to

https://www.thejointsolution.com