Topics to be Covered

- **Problem**: Longitudinal Joints Failures

- **Solution**: VRAM
  - *Void Reducing Asphalt Membrane*
    - Intro and terminology
    - Concept and Performance History
    - Application
    - Special Provisions
    - Research
    - Idaho SH 55 Project
    - Three Pillars of Sustainability
How difficult is it to find pavements like these?
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
- Water settles in rumble strips

Longitudinal Construction Joints

- **Issues**
  - Cannot achieve the same density at the joint as in the mat
  - Water and air intrusion due to permeability accelerates damage

- **Longitudinal construction joints**
  - Commonly, the first area requiring maintenance on a pavement
Air Voids from Joint Towards Center of Lane

Air Voids from Unconfined Centerline Joint

Distance from Joint, inches

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

Reduction in Expected Service Life

<table>
<thead>
<tr>
<th>Air Voids, %</th>
<th>6%</th>
<th>7%</th>
<th>8%</th>
<th>9%</th>
<th>10%</th>
<th>11%</th>
<th>12%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Life, Years</td>
<td></td>
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</tbody>
</table>

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.

Longitudinal Construction Joints Traditional Methods

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 (hot joint)
- Joint heater
- Notched wedge joint
- Cut off lower density unconfined edge
- Mill and inlay (confined)
Terminology

**V R A M**
Void Reducing Asphalt Membrane

**The Product Category**

**L J S**
Longitudinal Joint Sealant (Illinois Terminology)

**Asphalt Materials, Inc.**
Trade Name

**J-Band®**
Longitudinal Joint Improvement Plan

- Early 2000’s 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)

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
LJS Experimental Projects
IDOT US-51

CONTROL 15 YR OLD
VRAM SECTION 15 YR OLD

LJS Experimental Projects
IDOT IL-50

CONTROL 14 YR OLD
VRAM SECTION 14 YR OLD
LJS Experimental Projects
IDOT IL-26

CONTROL 14 YR OLD

VRAM SECTION 14 YR OLD

Attributes and Specs
Saves Time
Void Reducing Asphalt Membrane (VRAM)

- Thick application of hot-applied, polymer-modified asphalt (~1 gal/sq yd for 1 1/2" 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
- Modifies the AC mix at the longitudinal joint
- Protects underlying pavement layers
- Materials approach to improving joint performance

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. Joint density testing not required within 1 ft from joint.
VRAM Application Methods

Placed by pressure distributor with mechanical agitation in tank

Manual strike off box fed from melting kettle

Tow behind melter applicator

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**Special Provision – Material properties**

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic shear @ 88°C (unaged), G*/sin δ, kPa</td>
<td>1.00 min.</td>
<td>AASHTO T 315</td>
</tr>
<tr>
<td>Creep stiffness @ -18°C (unaged), Stiffness (S), MPa m-value</td>
<td>300 max. 0.300 min.</td>
<td>AASHTO T 313</td>
</tr>
<tr>
<td>Ash, %</td>
<td>1.0 – 4.0</td>
<td>AASHTO T 111</td>
</tr>
<tr>
<td>Elastic Recovery*, 100 mm elongation, cut immediately, 25°C, %</td>
<td>70 min.</td>
<td>ASTM D6084 Method A</td>
</tr>
<tr>
<td>Separation of Polymer, Difference in °C of the softening point (ring and ball)</td>
<td>3 max.</td>
<td>ASTM D7173</td>
</tr>
</tbody>
</table>
Special Provision – Rates by mix type and thickness
Coarse and fine-graded based on No. 8 sieve*

<table>
<thead>
<tr>
<th>VRAM Application Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse-Graded HMA Mixtures</strong></td>
</tr>
<tr>
<td>Overlay Thickness, in</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1 ¼</td>
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<tr>
<td>1 ½</td>
</tr>
<tr>
<td>1 ¾</td>
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<tr>
<td>≥ 2</td>
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<tr>
<td><strong>Fine-Graded HMA Mixtures</strong></td>
</tr>
<tr>
<td>Overlay Thickness, in</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1 ½</td>
</tr>
<tr>
<td>≥ 1 ½</td>
</tr>
<tr>
<td><strong>SMA Mixtures/SuperPave 5 Mixtures</strong></td>
</tr>
<tr>
<td>Overlay Thickness, in</td>
</tr>
<tr>
<td>1 ½</td>
</tr>
<tr>
<td>1 ¾</td>
</tr>
<tr>
<td>≥ 2</td>
</tr>
</tbody>
</table>

*No. 8 limits – 19-mm, 35% - 12.5-mm, 40% - 9.5-mm, 45%

Effect of VRAM on Voids and Asphalt at Joint

- The VRAM will migrate into the available air voids with heat and compaction
- Example HMA @ 6.0% AC, @ 1.5" thick/square yard = 9.9 lb of AC from mix
- VRAM @ 18” with VRAM weight per SY and total asphalt in joint area:

<table>
<thead>
<tr>
<th>Mix type</th>
<th>VRAM rate, lb/ft</th>
<th>VRAM, lb/SY</th>
<th>Total asphalt in joint area, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse-graded</td>
<td>1.47</td>
<td>8.8</td>
<td>10.8</td>
</tr>
<tr>
<td>SMA/SP5</td>
<td>1.26</td>
<td>7.6</td>
<td>10.6</td>
</tr>
<tr>
<td>Fine-graded</td>
<td>0.95</td>
<td>5.7</td>
<td>9.6</td>
</tr>
</tbody>
</table>

- Finer mixes have less inter-connected voids than coarse-graded mixes

Cross Sectional View at Longitudinal Joint
Current States* with VRAM Experience

- 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
- Nebraska
- New Mexico

Since 2002, VRAM has grown in popularity and is now found on roads across 23 states and the District of Columbia.
Improving HMA Pavements with a Void Reducing Asphalt Membrane

Growth of VRAM
Snapshot taken August 2022

VRAM Project Miles by Year - Includes Local Agency Projects

VRAM Performance History
9 IDOT VRAM experimental sections placed in 2002 – 2003 (oldest VRAM projects)
• IDOT research reports available
• Example - IL 50 Richton Park
IDOT Core Testing 14 Years After Service (2017)

- Asphalt content
- Migration
- Laboratory permeability testing
- I-FIT flexibility index (FI) values

Note: No LJS on left, with LJS on right. Example, not from IDOT research sections.

IDOT core testing 14 years after service (2017)

- Asphalt content nearly double for VRAM cores
- 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

Pixel Intensity by digital image analysis

IL-26

- Control
- J-Band

Lift Height (mm)

65% migration

Pixel Intensity by digital image analysis
Testing VRAM & Control Conditions

- Comparing VRAM to a traditional method
  - Encouragement to have a control section on a VRAM project when first starting out
  - Annual performance review focusing on the joint area

Cores on or near the centerline joint

<table>
<thead>
<tr>
<th>Good to Know</th>
<th>Must Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Content</td>
<td>Laboratory Permeability Testing</td>
</tr>
<tr>
<td>Migration</td>
<td>(vertical flow)</td>
</tr>
<tr>
<td></td>
<td>Flexibility or Cracking Test</td>
</tr>
</tbody>
</table>

- The use of VRAM reduces permeability and air void content, which reduces the intrusion of water into the pavement, indicating that good long-term pavement performance will be achieved
- Longitudinal cracking at the joints will be delayed relative to the control sections
Idaho SH 55, July 2019

- Contractor: Idaho Materials & Construction
- Applied by Western States Asphalt
- 5,280-foot demo project West of Marsing in Owyhee County, ID, starting 500 ft. east of US-95 to 500 ft. east of Edison Road
- Planned application at 18” wide and 0.95 lb/ft (±10%) for the 3” fine graded surface course.
- West half from 500 ft. east of US-95 to 2,640 east has VRAM, east half control
Idaho SH 55

Pillars of Sustainability
VRAM - Pillars of Sustainability

• Achieve Engineering goals while achieving Sustainability goals

VRAM/J-Band - Environmental Pillar

• AMI partnered with ClimeCo to study the sustainability of J-Band

• ClimeCo is a sustainability, climate change, and environmental commodities firm

• Goal: Build on J-Band life-extension to quantify its sustainability benefits
VRAM - Environmental Pillar

- GHG and air quality emissions estimated over the life cycle of the road: J-Band v. 3 alternatives
  - Longer life
  - Less maintenance
- Extraction, manufacturing, transport, application, and maintenance trips were quantified
- Quantified J-Band reduction in energy during construction and in maintenance compared to alternatives
- Final report is available on the ClimeCo Site
  - [What is a Life Cycle Assessment](#)
- To be presented at 2023 Transportation Research Board

What is a Life Cycle Assessment?

by: Gary Yoder and Josh Srinu | February 22, 2022

VRAM - Safety (Social) Pillar

- No density checks at the centerline during construction puts fewer workers at risk
- Rumble strips and distracted driving
- ClimeCo studied the reduction in maintenance for a road using J-Band, and calculated safety metrics
  - Far fewer injuries and fatalities using J-Band than alternatives in joint construction
VRAM - Economic Pillar

IDOT’s ROI: 3-5 times the cost of LJS

IDOT expects VRAM to provide a life extension of 3-5 years.

The benefit of this practice is 3-5 times the cost of the material, per IDOT.

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2021 TRB Paper Establishing Agency Value

Written with Illinois DOT – Accepted by Transportation Research Board

**Abstract**

Many states are looking for methods to improve longitudinal joint performance of their asphalt pavements since these joints often fail before the rest of the surface. With their inherently lower density, longitudinal joints fail by cracking, rewinding, and spalling because of the intrusion of air and water. Due to these longitudinal joint issues, and after trying several less-than-successful traditional solutions, the Illinois Department of Transportation (IDOT) developed a concept to seal the longitudinal joint region, but from the bottom up. Test sections were constructed in 2001 through 2003 to determine how a newly developed material, called longitudinal joint sealant (LJS), would improve joint performance. LJS is a highly-polymer-modified asphalt compound with fibers and is placed at the location of a longitudinal joint prior to paving. As mix is passed over it, the LJS melts and migrates up into voids in the low-density mix, making the mix impermeable to moisture while sealing the longitudinal joint itself. The IDOT test pavements were evaluated after twelve years and found to have longitudinal joints that exhibited significantly better performance than the control joint sections and were in similar or better condition than the rest of the pavement. Laboratory testing of cores showed decreased permeability and increased crack resistance of non-sealing joints with LJS as compared to similar non-sealing LJS. The life extension of the joint area is approximately three to five years, and the benefit is calculated to be three to five times the initial cost.

Keywords: Longitudinal joint, longitudinal joint sealant (LJS), void reducing asphalt membrane (VRAM)
VRAM Summary

- **Material solution** to improve performance at the joints
- Proven technology – multiple projects have been in place for over 15 years
- Reduces the need for joint maintenance
- Helps to improve safety & sustainability on the roads
- Life Cycle Cost Analysis can provide savings

Questions About VRAM?

For more information go to [https://www.thejointsolution.com](https://www.thejointsolution.com)

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