VRAM (Void Reducing Asphalt Membrane)
A Proactive Solution to Improving Longitudinal Joint Performance
Agenda

• Washington State DOT Study on Air Voids
• What is VRAM & how does it work?
• VRAM Performance History
  – Illinois DOT – 20 years
  – Northeast – 4 years
• Sustainability & Safety
• Alternative & Suggested Uses
• Summary of Takeaways
Washington State DOT Study

Why do joints fail early?

![Graph showing the relationship between In-Situ Air Voids (%) and Service Life (%)]

- As the In-Situ Air Voids (%) increase, the Service Life (%) decreases.
- The graph illustrates the negative impact of higher air voids on joint performance.

---

3 Improving Longitudinal Joint Performance
Air Voids from Joint Towards Center of Lane

Washington State DOT Study?

Centerline going towards interior of mat
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.
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

- 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
- All the above are “mechanical” solutions
Longitudinal Joint Performance 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)
VRAM

• What is VRAM? VRAM is a thick application of hot-applied, polymer-modified asphalt.
  • VRAM is not an emulsion.
  • True Grade 88-28, but with some additional properties added.

• The product is also referenced as:
  • LJS – Longitudinal Joint Sealant
  • VRAM – Void Reducing Asphalt Membrane

• Associated Asphalt’s VRAM/LJS product is J-Band®
## VRAM Special Provision

<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.</td>
<td>AASHTO T 313</td>
</tr>
<tr>
<td></td>
<td>0.300 min.</td>
<td></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>AASHTO T301</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, AASHTO T53</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>
<th>Coarse-Graded HMA Mixtures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overlay Thickness, in</td>
<td>VRAM Width, in.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>1 ¼</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>1 ½</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>1 ¾</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>≥ 2</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fine-Graded HMA Mixtures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlay Thickness, in</td>
<td>VRAM Width, in.</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>1 ¼</td>
<td>18</td>
</tr>
<tr>
<td>≥ 1 ½</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SMA Mixtures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlay Thickness, in</td>
<td>VRAM Width, in.</td>
</tr>
<tr>
<td>1 ½</td>
<td>18</td>
</tr>
<tr>
<td>1 ¾</td>
<td>18</td>
</tr>
<tr>
<td>≥ 2</td>
<td>18</td>
</tr>
</tbody>
</table>

*No. 8 limits – 19-mm, 35% - 12.5-mm, 40% - 9.5-mm, 45%
Apply a heavy band of polymer modified binder in the area where the new paving joint will be placed.

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

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

Polymer modified binder migrates into the HMA at the joint.
Improving Longitudinal Joint Performance

Crack Progression

- **No J-Band**
- **J-Band**

**New**

1 - 3 years old

3 - 6 years old

6 - 10 years old

10 - 15 years old
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.
Where is VRAM applied?

- Joint defined as
  - Within travelled way
- Or between
  - travelled way and auxiliary lane
  - travelled way and paved shoulder
  - auxiliary lane and paved shoulder
VRAM Application Methods

Placed by pressure distributor with mechanical agitation in tank

Manual strike off box fed from melting kettle

Tow behind melter applicator
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>11.3</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 smaller and less inter-connected voids than coarse-graded mixes
Current States with VRAM Experience

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

- 9 IDOT VRAM 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 Field Performance
IDOT D1 IL-50 Richton Park After 14 Years

VRAM Test Section

Control Section
VRAM Field Performance
IDOT D2 Cedarville IL-26 After 14 Years

All pictures were taken in 2017

VRAM Test Section

Transition from Control Section to VRAM Section

Control Section
Flexibility Index Data from 15 year Old Projects

- US-51 J-Band: 22
- US-51 Control: 0.8
- IL-26 J-Band: 9
- IL-26 Control: 0.2
Many approaches to improving the performance of asphalt pavement longitudinal joints have been tried by various agencies with mixed or marginal success.

IDOT looked at a bottom-up material approach to seal the voids in the lower-density longitudinal joint area, with the result being lower permeability and an improvement in predicted laboratory flexibility and field performance.

The high polymer LJS material has rut resistant and crack resistant binder properties and has been easily imbedded into the construction process of surface courses.

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.
Northeast Field Observations and Performance
PennDOT Project I-380; November 2019 Field View

No VRAM

VRAM
PennDOT Project I-380; December 2021 Field View

- VRAM joint after 3 Years
- VRAM joint after 3 years
I-380 Test Data from 3-Year Old Cores

Average of Air Voids (%) by Sample Type

- Control: 10.5%
- VRAM: 8.2%
I-380 Test Data from 3-Year Old Cores

Average of Permeability (ft/day) by Sample Type

- Control: 26.28 ft/day
- VRAM: 0.44 ft/day
I-380 Test Data from 3-Year Old Cores

Average of Ideal-CT Index by Sample Type

- Control: 325
- VRAM: 1274
VRAM Development at PennDOT

- 2018 – Initial Demonstration Project
- 2019/2020 – Evaluation Period
- 2020 – Begin letting on a few projects for 2021
- 2021 – 1 Project in each District (Except 2,3 & 10)
  - Working on Standard Special Provision (SSP)
  - Cores for testing from 1st Project
- 2022 – Introduce SSP
  - Work with Districts to get 4-5 in each location
  - Continue exchange of information
  - First draft of CT has been reviewed
  - Draft spec due out by end of 2022
NYSDOT Southern State Parkway Project

Figure 3 – Falling Head Permeability Apparatus (not to scale) Used in Study

The permeability results are shown in Table 2 and Figure 4 below. The average permeability measured in the Control cores was 1,561.2 cm/sec x 10^{-5} (44.3 ft/day). Meanwhile, the average permeability for the VRAM cores was 177.7 cm/sec x 10^{-5} (5.0 ft/day). Overall, the VRAM cores had permeability values almost 9 times lower than the Control cores. Pictures of the Control cores and VRAM cores prior to permeability testing can be found in Appendix A.

Table 2 – Permeability Results of NYSDOT Southern State Parkway J-Band Trial

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Core ID</th>
<th>Air Voids (%)</th>
<th>Permeability (cm/s x 10^{-5})</th>
<th>Permeability (ft/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ave</td>
<td>Std Dev</td>
</tr>
<tr>
<td>Mainline Core</td>
<td>PC1</td>
<td>4.7</td>
<td>2.2</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>PC2</td>
<td>11.1</td>
<td>1605.4</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>PC3</td>
<td>10.3</td>
<td>1979.9</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>PC4</td>
<td>7.2</td>
<td>1098.3</td>
<td>180.9</td>
</tr>
<tr>
<td>Conventional Joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVJ1</td>
<td>5.8</td>
<td>23.4</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>PVJ2</td>
<td>8.2</td>
<td>124.6</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>PVJ3</td>
<td>5.8</td>
<td>7.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>PVJ4</td>
<td>10.3</td>
<td>555.2</td>
<td>10.7</td>
</tr>
</tbody>
</table>
For this study, the IDEAL-CT Index testing was conducted using Rutgers University’s InstroTek Smart Jig on a Pine Instruments screw driven compression machine. All test specimens were conditioned at 25°C overnight in an environmental chamber prior to testing.

The IDEAL-CT Index results for the PATP MP 94 to 99 J-Band Trial are shown in Table 4. The results indicate that the VRAM section cores had a higher average fracture energy (31,880 vs 7559 J/m²) and resulted in a higher average IDEAL-CT Index (1829.6 vs 824.6). This indicates that the VRAM section cores need more force (or energy) to separate the longitudinal construction joint than the conventional joint construction practices used on the PATP MP 94 to 99. The detailed results from the testing can be found in the Appendix B of the report.

### IDEAL-CT Index Results of PATP MP 94 to 99 J-Band Trial

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Core ID</th>
<th>Air Voids (%)</th>
<th>Fracture Energy</th>
<th>IDEAL-CT Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>PC1</td>
<td>6.0</td>
<td>7,197.7</td>
<td>776.7</td>
</tr>
<tr>
<td></td>
<td>PC2</td>
<td>7.1</td>
<td>8,145.1</td>
<td>1128.9</td>
</tr>
<tr>
<td></td>
<td>PC3</td>
<td>6.4</td>
<td>7,333.5</td>
<td>568.1</td>
</tr>
<tr>
<td>VRAM</td>
<td>PVJ1</td>
<td>4.6</td>
<td>44,014.7</td>
<td>2524.3</td>
</tr>
<tr>
<td></td>
<td>PVJ2</td>
<td>4.8</td>
<td>34,781.4</td>
<td>1784.9</td>
</tr>
<tr>
<td></td>
<td>PVJ3</td>
<td>5.9</td>
<td>18,696.3</td>
<td>749.1</td>
</tr>
<tr>
<td></td>
<td>PVJ4</td>
<td>5.3</td>
<td>30,030.9</td>
<td>2260.1</td>
</tr>
</tbody>
</table>
MDTA I-95 – Air Voids

Air Voids, %

Control: 8.0
VRAM: 5.7
MDTA I-95 – Permeability

Permeability, ft/day

Control: 160.87 ft/day
VRAM: 0.00 ft/day
MDTA I-95 – IDEAL-CT Index

IDEAL-CT Index

Control: 857.9
VRAM: 2776.1
MDTA I-95

MDTA I-95 Project Test Results:

- Air Voids decreased by 29%
- Permeability decreased to 0.00
- IDEAL CT Cracking Index increased by 224%
Permeability

Average Permeability (ft/day)

Control: 48.19 ft/day
VRAM: 3.34 ft/day
IDEAL-CT

Average Ideal-CT

Control: 763.13
VRAM: 1,659.57
Air Voids Results

Average of Air Voids (%)

Control: 10.05%
VRAM: 8.66%
What is the Data Showing Us?

• Testing for East Coast project by 3rd Party Lab
  • Constructed Air Voids using AASHTO T166
  • Permeability using (FDOT) test method, FM 5-565
  • Tensile Strength using IDEAL-CT
• Results:
  • Air Voids average 5% improvement
  • Permeability on an average, showed improvements of 16X control joint
  • Tensile Strength/Cracking Resistance increased by 90%-150%
• Rutgers University- Thomas Bennert, PH.D.
• The decrease in air voids, decrease in permeability and increase in tensile strength/IDEAL-CT
Index of the longitudinal joint would suggest that the initial performance of the “Various Projects” VRAM longitudinal joint section is much greater than the conventional longitudinal joint section (Control).
There has been movement towards developing a framework for a LEED-type system for infrastructure. Greenroads and ENVISION were mentioned as ones to watch.
## Sustainability and Safety

<table>
<thead>
<tr>
<th></th>
<th>J-Band VRAM</th>
<th>Joint Adhesive</th>
<th>IR Heater</th>
<th>PWTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg per year GHG (kg CO2e)</td>
<td>48.5</td>
<td>50.6</td>
<td>52.8</td>
<td>358.6</td>
</tr>
<tr>
<td>Air quality (lb VOC/CO/Nox/PM2.5)</td>
<td>0.2</td>
<td>2.1</td>
<td>1.8</td>
<td>10.9</td>
</tr>
<tr>
<td>Injuries per million miles</td>
<td>4</td>
<td>58</td>
<td>64</td>
<td>75</td>
</tr>
<tr>
<td>Fatalities per million miles</td>
<td>0.1</td>
<td>1.9</td>
<td>2.1</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Alternative and Suggested Uses

- Unconfined outside edge
- Bridge waterproof system
- Suggested under rumble strips
Takeaways

• 20 years of proven results with VRAM(J-Band®)
• 9" + 9" = 18" (The area that needs addressed)
• Crack Resistance Improved
• Permeability Reduced
• The Bottom-Up Solution
• Promotes Sustainability and Improves Safety
• Adds 3-5 years of service life (pays for itself)
• ROI: https://thejointsolution.com/calculator/
Questions?

- For more information go to https://www.thejointsolution.com
- mworden@associatedasphalt.com
- 717-578-6268