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REPORT TITLE:

EVALUATION OF "J-BAND" LONGITUDINAL JOINT SEALANT ON PENNSYLVANIA TURNPIKE MP 94-99 (WESTERN PA)

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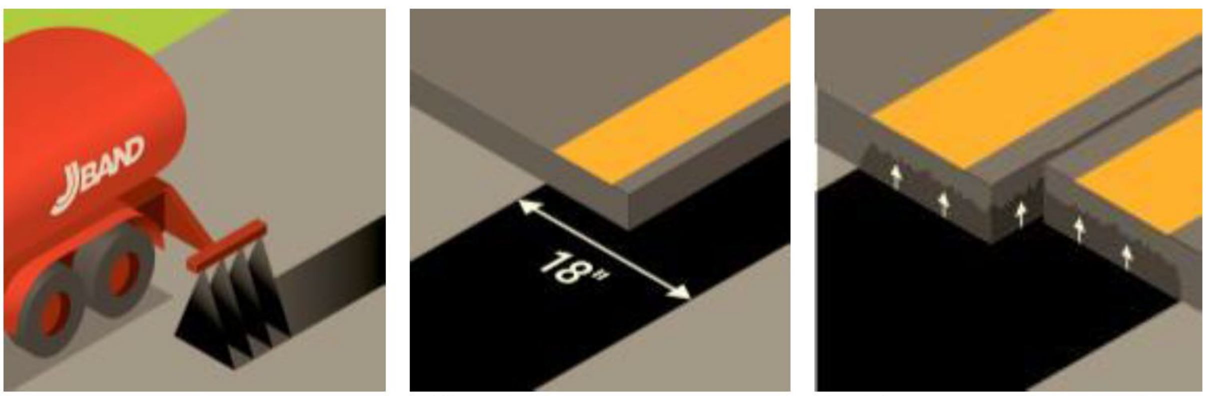
BACKGROUND

One of the major issues with the construction of asphalt pavements is the inability to achieve good pavement density in the immediate area of the longitudinal construction joints. High voids around the longitudinal joint allows water to enter the asphalt pavement, greatly compromising the durability of the asphalt material in the immediate area of the joint, as well as potentially allowing water deeper into the pavement structure. Data collected from various state agencies across the country have clearly identified poor longitudinal joint density as one of the main contributors to reducing the service life of the asphalt pavements.

To help combat the potential for water intrusion of the longitudinal joint, a product called J-Band can be applied prior to paving. The J-Band is a void reducing asphalt membrane (VRAM) that "wicks" upward in the longitudinal joint area during paving, essentially filling the air voids remaining in the longitudinal construction joint. Figure 1 below shows the J-Band application process during construction. The J-Band material is polymer-modified asphalt liquid applied hot over an 18-inch wide band in the immediate area of where the longitudinal joint is proposed. If the construction is a mill and fill application, a 9-inch band on the milled surface is applied prior to the paving (Figure 2).



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

Polymer modified binder migrates into the HMA at the joint

Figure 1 – J-Band Application Process

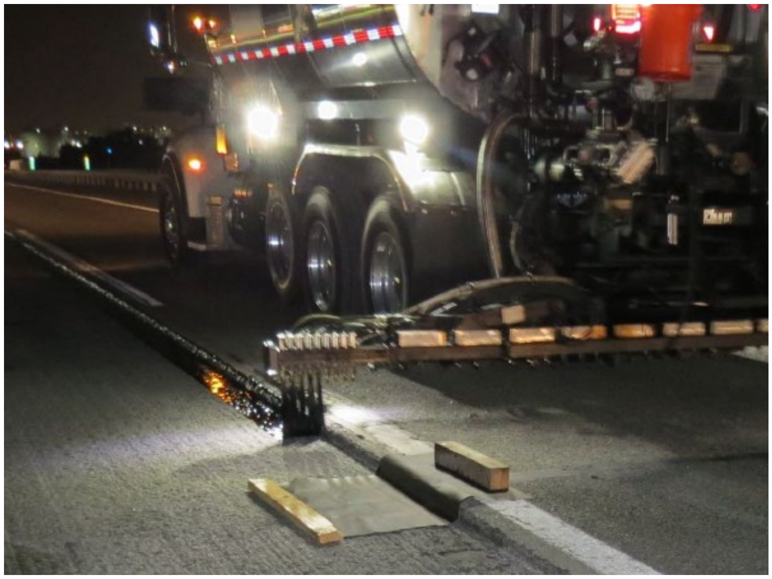


Figure 2 – New Jersey Turnpike Project (Also Showing Calibration of Application Rate)

Field cores were recovered from the Pennsylvania Turnpike (PATP) between mileposts 95 to 98 to evaluate the functional and structural performance of the longitudinal joint in a Control area and an area where J-Band was applied. The longitudinal joint cores, called “Control” in the report, were constructed using a conventional butt joint and cored on 9/22/22. The longitudinal joint cores, called “VRAM” in the report, were constructed using the identical joint construction procedure except that the J-Band product was applied at the joint area prior to paving. Cores from the VRAM area were also recovered on 9/22/22. The J-Band on this project was applied at a rate of 1.50 lb/ft. The asphalt mixture used was a 12.5 mm nominal maximum aggregate size (NMAS) stone matrix asphalt (SMA) using a PG64E-22 and compacted to a targeted 2.0 inches thick surface layer. Prior to the SMA, a 19mm NMAS was placed at a target thickness of 3.0 inches. In the end, four (4) field cores from the VRAM section and three (3) cores from the Control section were provided to Rutgers University for evaluation.

LABORATORY PROGRAM

A laboratory program was conducted to evaluate the “performance” of the longitudinal joint. This consisted of testing for the constructed air voids of the longitudinal joint, as well as the permeability of the core taken immediately over the longitudinal joint. The “bonding strength” of the longitudinal joint was indexed using the IDEAL-CT test method (ASTM D8225). When cylindrical specimens are tested in the indirect tension mode (i.e. – on its side), a state of high tension is created down the middle of the specimen. If the J-Band product is providing better bonding in the longitudinal joint, it should result in higher IDEAL-CT Index values.

Since the testing program consisted of utilizing the same specimen for all testing, it was important to take slow and methodical steps to ensure damage was not occurring to the specimens during any stage. The process implemented to conduct the laboratory testing is noted below.

1. Trim the surface lift using a wet saw to remove any underlying pavement layer while creating a flat surface for permeability and IDEAL-CT testing.
2. Dry the specimen at room temperature in front of a fan overnight and then complete specimen drying using InstroTek's CoreDry system (AASHTO R79/ASTM D7227).
3. Determine the bulk specific gravity of the trimmed field core in accordance to AASHTO T166.
4. Determine the falling head permeability in accordance with Florida Department of Transportation (FDOT) test method, FM 5-565, *Florida Method of Test for Measurement of Water Permeability of Compacted Asphalt Pavement Mixtures*
5. Determine the IDEAL-CT Index of the field cores in accordance with ASTM D8225.
6. Breakdown the tested field cores, determine the maximum specific gravity in accordance with AASHTO T209, and then calculate the air voids of the field core taken immediately over the longitudinal joint.

Density and Air Void Determination

The air voids of the recovered field cores were determined in accordance to AASHTO T269, *Standard Method of Test for Percent Air Voids in Compacted Dense and Open Asphalt Mixtures*. It was determined to not use AASHTO T331, *Standard Method of Test for Bulk Specific Gravity (G_{mb}) and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method*, to determine the bulk specific gravity of the field core in fear that the pressure of the vacuum bag sealing the specimen could compromise the test specimen. As per AASHTO T166, when water absorption is greater than 2.0%, the compacted specimen should be dried and retested using either AASHTO T275 (paraffin coated) or T331. The high water absorption is an indication of high porosity and the use of AASHTO T166 may lead to incorrect bulk specific gravity measurements (most likely show lower air voids than actually present). However, to minimize any additional and unnecessary handling of the field cores, the bulk specific gravity of the cores were solely measured using AASHTO T166 for air void determination. The results are shown in Table 1. Overall, the Control section resulted in an average air voids of 6.5% (0.5% standard deviation) with the VRAM section resulting in an average air voids of 5.2% (0.6% standard deviation).

It should be noted that the maximum specific gravity (Gmm) was determined for each core individually and used for the air void calculation of each core, respectively. Determining Gmm separately is important as it has been found that the length or amount of the longitudinal joint found in the cores can vary depending on how well positioned the core barrel was over the joint during coring. This can greatly change the amount of joint adhesive and/or J-Band in the core. In addition, the J-Band product will "wick" upwards into the core, thereby changing the constituents of the asphalt mix in the core (i.e. – more asphaltic liquid material than stone material). Therefore, assuming a constant Gmm for the entire longitudinal joint area could lead to significant errors in calculating air voids.

Table 1 – Measured Air Voids for Field Cores Recovered for PATP MP 94 to 99 J-Band Trial

Standard Method of Test for

Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens

AASHTO Designation: T 166-12

Standard Method of Test for

Percent Air Voids in Compacted Dense and Open Asphalt Mixtures

AASHTO Designation: T 269-11[1]
ASTM Designation: D 3203-05

Project ID: VRAM PA Turnpike MP 95 to 98
Technician: Drew/Kyle/ Chris
Date: 10/10/2022

Sample ID: Field Cores
Mix Type: 12.5mm SMA, PG64E-22
Joint Type: Butt Joint

Sample Type	Sample ID	Wt in Air (grams)	Wt in Water (grams)	SSD Water (grams)	Bulk Specific Gravity (g/cm^3)	Max. Specific Gravity (g/cm^3)	Air Voids (%)	Water Absorption (%)
Core	PC1	1796.8	1014.2	1807.4	2.265	2.411	6.0	**1.3**
Core	PC2	1857.5	1048.4	1876.3	2.244	2.415	7.1	**2.3**
Core	PC3	2221.8	1269.2	2245.9	2.275	2.43	6.4	**2.5**
Core	PVJ1	1687.6	946.9	1695.5	2.254	2.364	4.6	**1.1**
Core	PVJ2	1487.6	837.6	1495.1	2.263	2.377	4.8	**1.1**
Core	PVJ3	1652.1	924.9	1662.0	2.241	2.381	5.9	**1.3**
Core	PVJ4	1818.2	1019.5	1824.2	2.259	2.387	5.3	**0.7**

Falling Head Permeability, FM 5-565

The permeability of the field cores was measured using the Florida Department of Transportation (FDOT) test method, FM 5-565, *Florida Method of Test for Measurement of Water Permeability of Compacted Asphalt Pavement Mixtures.* The falling head permeability apparatus, Figure 3, is used to determine the rate of vertical flow through the specimen. Water in a graduated cylinder is allowed to flow through a saturated asphalt sample and the interval of time taken to reach a known change in head pressure is recorded. The coefficient of permeability is then determined based on Darcy's Law.

$$k = \frac{aL}{At} ln\left(\frac{h_1}{h_2}\right) t_c$$

where,

k = coefficient of permeability (cm/s)
a = inside cross-sectional area of the buret (cm^2)
L = average thickness of the test specimen (cm)
t = elapsed time between h_1 and h_2 (seconds)
h_1 = initial head pressure of water across the test specimen (cm)
h_2 = final head pressure of water across the test specimen (cm)
t_c = temperature correction for water viscosity if not at 20°C

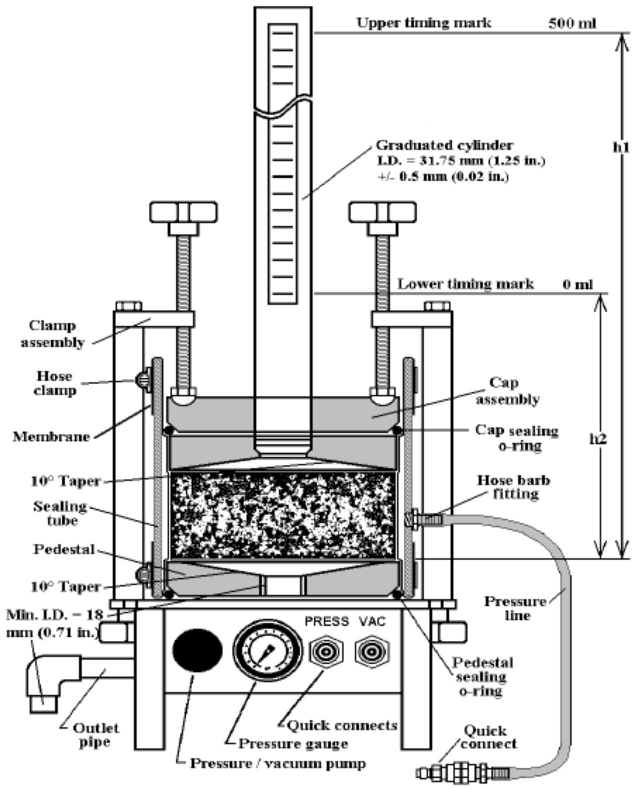


Figure 3 – Falling Head Permeability Apparatus (not to scale) Used in Study

The permeability results are shown in Tables 2 and 3 and Figures 4 and 5 below. Figure 4 contains the permeability measurements using full thickness of field cores recovered from the VRAM joint area (i.e. – 12.5mm SMA + J-Band + 19mm HMA). Figure 4 clearly shows how the J-Band seals off the 19mm HMA and does not allow water to permeate past the 12.5mm SMA surface layer. Figure 5 shows the impact of the J-Band migrating upward into the joint area and sealing off some of the interconnected voids of the constructed joint in the surface layer. The average permeability measured in the 12.5mm SMA Control surface course cores was 623.1 cm/sec x 10^{-5} (17.7 ft/day). Meanwhile, the average permeability for the 12.5mm SMA VRAM surface course cores was 26.0 cm/sec x 10^{-5} (0.74 ft/day). Overall, the Control cores had permeability values 24 times greater than the VRAM cores. Pictures of the Control cores and VRAM cores prior to permeability testing can be found in Appendix A.

Table 2 – Permeability Results for PATP MP 94 to 99 J-Band Trial (Full Core)

Sample Type	Core ID	Air Voids (%)	Permeability (cm/s x 10^{-5})		Permeability (ft/d)	
			Ave	Std Dev	Ave	Std Dev
Control Core	PC1	N.A.	227.9	5.44	6.46	0.15
	PC2	N.A.	1073.3	16.24	30.42	0.46
	PC3	N.A.	1744.9	53.97	49.46	1.53
VRAM Core	PVJ1	N.A.	0.0	0.00	0.00	0.00
	PVJ2	N.A.	0.0	0.00	0.00	0.00
	PVJ3	N.A.	0.0	0.00	0.00	0.00
	PVJ4	N.A.	0.1	0.10	0.00	0.00

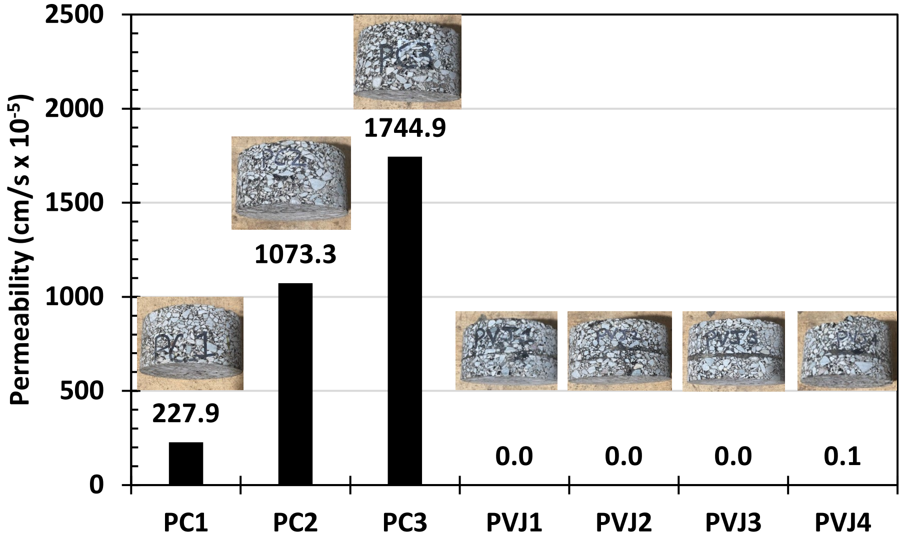


Figure 4 – Permeability for PATP MP 94 to 99 J-Band Trial (Full Core)

Table 3 – Permeability Results for PATP MP 94 to 99 J-Band Trial (12.5mm SMA Surface Lift Only)

Sample Type	Core ID	Air Voids (%)	Permeability (cm/s x 10^{-5})		Permeability (ft/d)	
			Ave	Std Dev	Ave	Std Dev
Control (Surface Only)	PC1	6.0	120.7	1.24	3.42	0.04
	PC2	7.1	665.7	0.96	18.87	0.03
	PC3	6.4	1082.9	1.55	30.70	0.04
VRAM (Surface Only)	PVJ1	4.6	0.0	0.00	0.00	0.00
	PVJ2	4.8	0.0	0.00	0.00	0.00
	PVJ3	5.9	85.8	0.13	2.43	0.00
	PVJ4	5.3	18.1	0.75	0.51	0.02

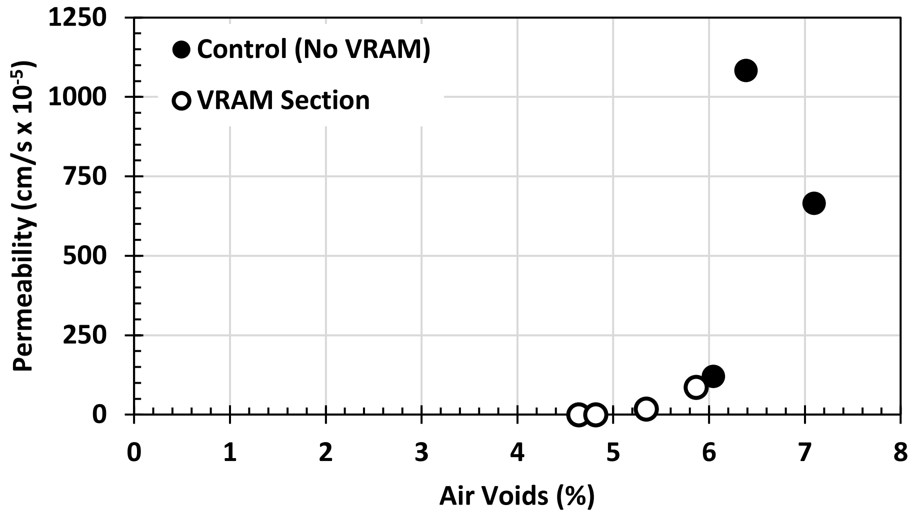
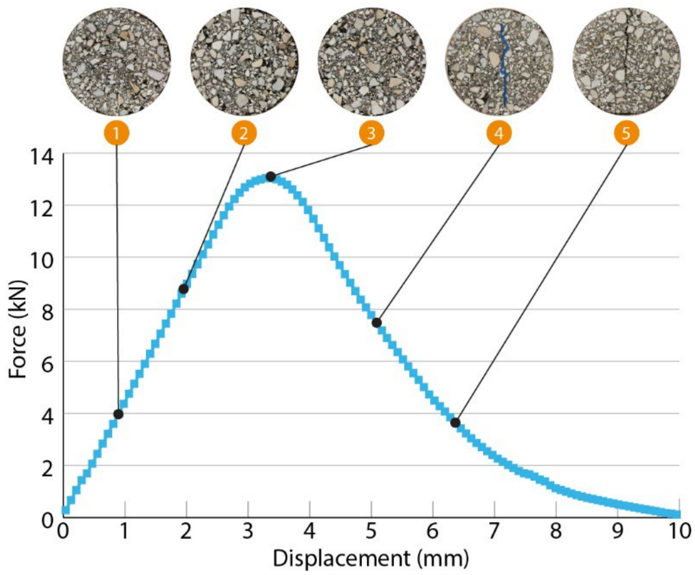


Figure 5 – Permeability vs Measured Air Voids for PATP MP 94 to 99 J-Band Trial (12.5mm SMA Surface Lift Only)

IDEAL-CT Index

The IDEAL-CT is similar to the traditional indirect tensile strength test, and it is run at the room temperature (25ºC) with cylindrical specimens at a loading rate of 50 mm/min. in terms of cross-head displacement. Any size of cylindrical specimens with various diameters (100 or 150 mm) and thicknesses (38, 50, 62, 75 mm, etc.) can be tested. For mix design and laboratory QC/QA, it is proposed to use the same specimen size as the Hamburg wheel tracking test: 150 mm diameter and 62 mm height, since agencies are familiar with molding such specimens. Either lab-molded cylindrical specimens or field cores can be directly tested with no need for instrumentation, gluing, cutting, notching, coring or any other preparation.

Figure 6 shows a typical IDEAL-CT: cylindrical specimen, test fixture, test temperature, loading rate, and the measured load vs. displacement curve.



Test temperature: 25°C
Loading rate: 50 mm/min.
Specimen: cylindrical specimen without cutting, gluing, instrumentation, drilling, or notching.

Figure 6 - IDEAL-CT: Specimen, Fixture, Test Conditions, and Typical Result

After carefully examining the typical load-displacement curve and associated specimen conditions at different stages (Figure 6), the authors chose the post-peak segment to extract cracking resistance property of asphalt mixes. Note that with the initiation and growth of the macro-crack, load bearing capacity of any asphalt mix will obviously decrease, which is the characteristic of the post-peak segment.

$$CT_{Index} = \frac{G_f}{|m_{75}|} \times \left(\frac{l_{75}}{D}\right) \qquad (2)$$

where Gf is the energy required to create a unit surface area of a crack; $|m_{75}| = \left|\frac{P_{85}-P_{65}}{l_{85}-l_{65}}\right|$ is the secant slope is defined between the 85 and 65 percent of the peak load point of the load-displacement curve after the peak; and l_{75} is deformation tolerance at 75 percent maximum load (Figure 7).

Generally, the larger the Gf, the better the cracking resistance of asphalt mixes. The stiffer the mix, the faster the cracking growth, the faster the load reduction, the higher the $|m_{75}|$ value, and consequently the poorer the cracking resistance. It is obvious that the mix with a larger $\frac{l_{75}}{D}$ and better *strain* tolerance has a higher cracking resistance than the mix with a smaller $\frac{l_{75}}{D}$.

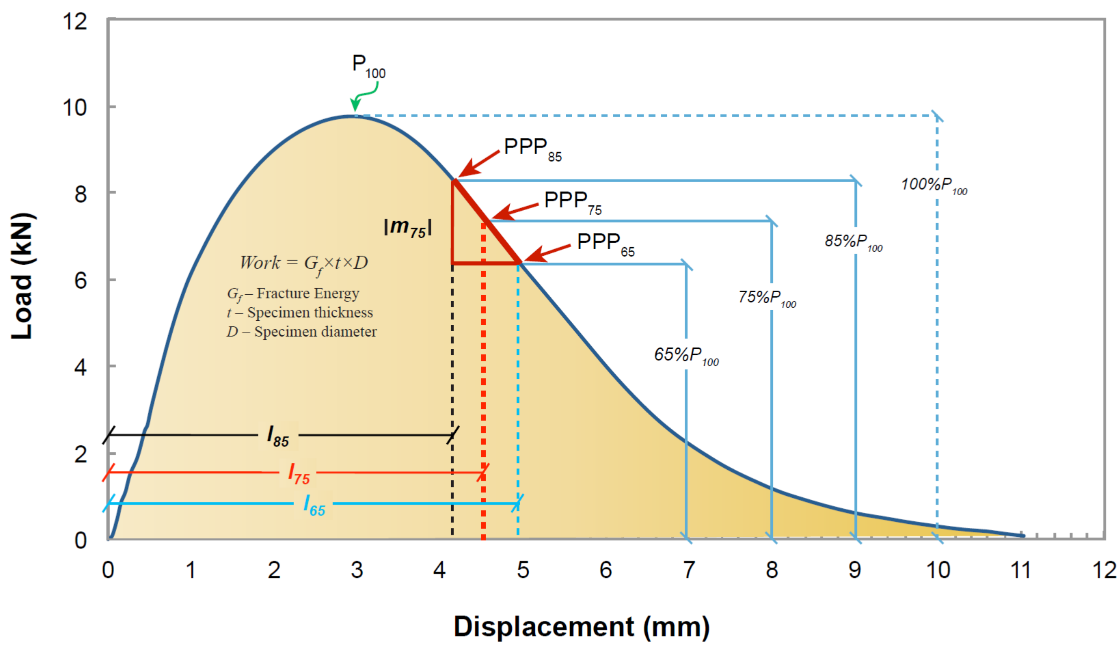


Figure 7 - Illustration of the PPP75 Point and Slope $|m_{75}|$

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/m^2) 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.

Table 4 – IDEAL-CT Index Results of PATP MP 94 to 99 J-Band Trial

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

CONCLUSIONS

A field trial was conducted to evaluate the Void Reducing Asphalt Membrane (VRAM) product called J-Band to help improve the performance of longitudinal construction joints in asphalt pavements. The field trial took place on the Pennsylvania Turnpike between mileposts 94 to 99 with both a Control and VRAM section. Field cores recovered from the longitudinal joint were evaluated for air voids, permeability and cracking resistance using the IDEAL-CT Index test procedure. The results of the laboratory testing showed;

- The air void determination indicated that the Control section had a slightly higher compacted air voids compared to the VRAM section for the 12.5mm SMA surface course with the butt joint longitudinal joint construction (6.5% vs 5.2%, respectively).
- The application of the J-Band product significantly reduced the permeability of the compacted asphalt at the longitudinal joint. On average, the permeability of the J-Band treated longitudinal joint was approximately twenty-four (24) times slower than the conventional longitudinal joint. When permeability testing was conducted using the entire core provided (12.5mm SMA + J-Band + 19mm HMA), the VRAM sections were determined to be impermeable, clearly indicating the VRAM seals off the underlying asphalt layers below the longitudinal joint area.
- The application of the J-Band product significantly improved the cracking resistance of the longitudinal joint as determined using the IDEAL-CT Index test procedure. The application of the J-Band product increased the IDEAL-CT Index of the longitudinal joint by over four (4) times compared to the IDEAL-CT Index values measured in the Control cores.

The reduction in air voids, significant decrease in permeability and increase in cracking resistance as measured by the IDEAL-CT Index of the longitudinal joint would suggest that the performance of the Pennsylvania Turnpike MP 94 to 99 (Western PA) VRAM longitudinal joint section is greater than the conventional longitudinal joint areas when constructed with the butt joint practices on this project.

APPENDIX A – CONTROL AND VRAM CORES

Figure A1 – Core PC1 – Control Joint Core

Figure A2 – Core PC2 – Control Joint Core

Figure A3 – Core PC3 – Control Joint Core

Figure A4– Core PVJ1 – VRAM Core

Figure A5 – Core PVJ2 - VRAM Core

Figure A6 – Core PVJ3 – VRAM Core

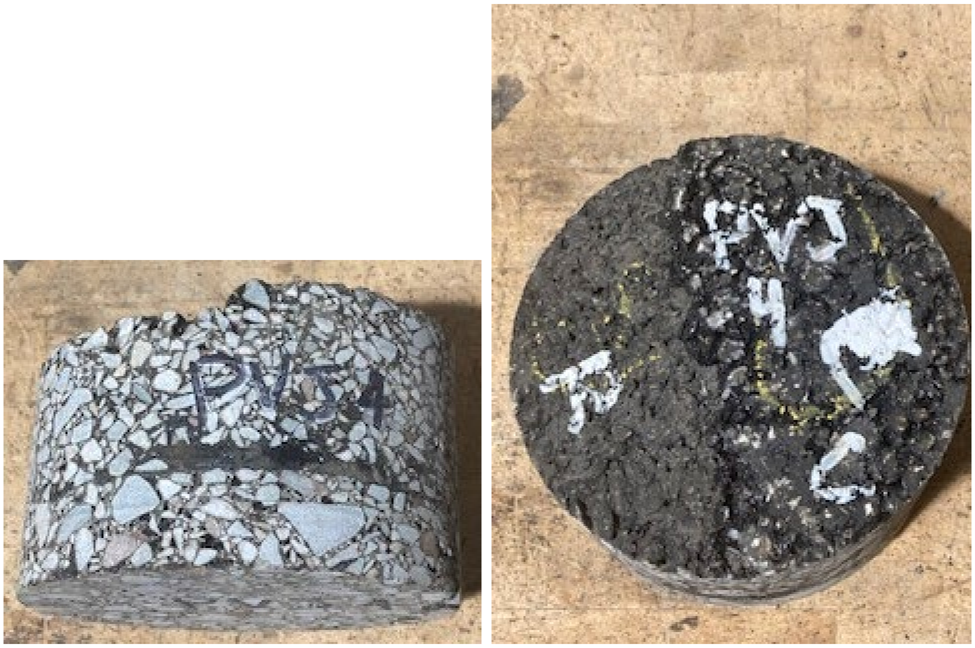


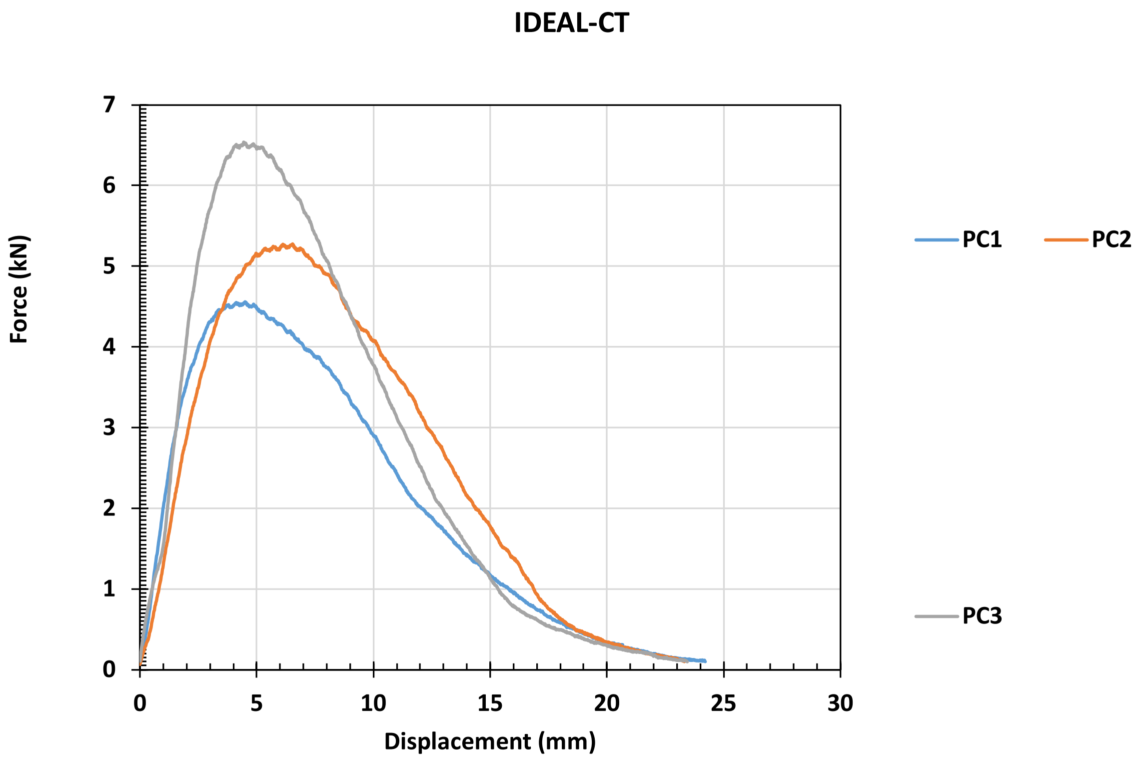
Figure A7 – Core PVJ4 – VRAM Core

APPENDIX B - IDEAL-CT TESTING RESULTS

ASTM D8225 - Standard Test Method for Determination of Cracking Tolerance Index of Asphalt Mixture Using the Indirect Tensile Cracking Test at Intermediate Temperatures

Project Name: 2022 VRAM
Mix Type: PATP MP 94 to 99, Control Cores
Test Temperature: 25C
Institution: Rutgers University
Date Tested: 12-Oct-22
Technician: Haas

Specimen ID	Air Voids (%)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	(L) (mm)	Tensile Strength (kPa)	Fracture Energy (Gf) (LLD)	Slope (S)	Gf/S	Gf/S * $(L/D)^2$	CT Index
PC1	6.0	46.0	150.3	4.6	8.9	419.7	7197.7	0.41	17757.6	45.8	776.7
PC2	7.1	48.9	150.2	5.3	10.3	457.7	8145.1	0.39	20970.0	77.1	1128.9
PC3	6.4	57.4	150.2	6.5	8.2	483.0	7333.5	0.65	11214.6	31.1	568.1
Average	**6.5**	**50.8**	**150.2**	**5.5**	**9.1**	**453.4**	**7558.8**	**0.48**	**16647.4**	**51.3**	**824.6**
Std Dev	**0.5**	**5.9**	**0.0**	**1.0**	**1.0**	**31.9**	**512.3**	**0.15**	**4971.6**	**23.5**	**283.4**
COV (%)	**8.2**	**11.6**	**0.0**	**18.4**	**11.5**	**7.0**	**6.8**	**30.8**	**29.9**	**45.8**	**34.4**



ASTM D8225 - Standard Test Method for Determination of Cracking Tolerance Index of Asphalt Mixture Using the Indirect Tensile Cracking Test at Intermediate Temperatures

Project Name: 2022 VRAM
Mix Type: PATP MP 94 to 99, VRAM Cores
Test Temperature: 25C
Institution: Rutgers University
Date Tested: 12-Oct-22
Technician: Haas

Specimen ID	Air Voids (%)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	(L) (mm)	Tensile Strength (kPa)	Fracture Energy (Gf) (LLD)	Slope (S)	Gf/S	Gf/S * $(L/D)^2$	CT Index
PVJ1	4.6	43.3	150.1	5.1	12.3	500.3	12445.7	0.28	44014.7	207.3	2524.3
PVJ2	4.8	38.7	150.1	4.0	12.4	443.6	9712.3	0.28	34781.4	146.9	1784.9
PVJ3	5.9	42.9	150.1	4.5	8.7	448.0	7627.4	0.41	18696.3	43.4	749.1
PVJ4	5.3	47.3	150.1	5.5	14.8	494.3	10588.8	0.35	30030.9	222.9	2260.1
Average	**5.2**	**43.0**	**150.1**	**4.8**	**12.0**	**471.6**	**10093.6**	**0.33**	**31880.8**	**155.1**	**1829.6**
Std Dev	**0.6**	**3.5**	**0.0**	**0.6**	**2.5**	**29.9**	**2000.4**	**0.06**	**10534.0**	**81.4**	**782.6**
COV (%)	**10.7**	**8.2**	**0.0**	**13.4**	**20.9**	**6.3**	**19.8**	**18.6**	**33.0**	**52.5**	**42.8**