AAPTP
Airport Asphalt Pavement Technology Program

Improving Performance of Longitudinal Joints in Airfield Asphalt Pavements

Volume 2: Inspections of Existing and New Projects with Different Longitudinal Joint Construction Techniques

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Credit: NAPA

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The Airport Asphalt Pavement Technology Program (AAPTP) is a cooperative agreement effort between the **National Asphalt Pavement Association** (NAPA) and the **Federal Aviation Administration** (FAA) to advance asphalt pavements and pavement materials. The AAPTP advances solutions for asphalt pavement design, construction, and materials deemed important to airfield reliability, efficiency, and safety. The program leverages NAPA's unique technology implementation capabilities with assistance from the FAA and industry to advance deployment and adoption of innovative asphalt material technologies.

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The maps in Figure 5, Figure 47, and Figure 48 in this document were modified. The original maps are the copyright property of Google® Earth™ and can be accessed from https://www.google.com/earth/ (Google® 2021). The map overlays show field test locations used for this research project.



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Foreword

The Federal Aviation Administration (FAA) advisory circular (AC) 150/5370-10H (2018), *Standards for Specifying Construction of Airports*, requires that longitudinal joints be cut back and an asphalt tack coat or other approved product be applied to the cut face prior to placing an adjacent lane. Contractors may also be permitted to use joint heaters to aid in constructing longitudinal joints. However, despite the FAA's requirement to cut back longitudinal joints and the additional, rigorous joint density acceptance requirement, which have been in place for nearly two decades, longitudinal joint cracking and raveling continue to be leading causes of deterioration in airfield asphalt pavements. While FAA AC 150/5380-6C (2014), *Guidelines and Procedures for Maintenance of Airport Pavements*, provides guidance on sealing cracks at joints, there remains a need to evaluate improved materials and methods.

A new method with potential for preserving joint integrity in flexible highway pavements is the use of a void-reducing asphalt membrane (VRAM). VRAM products are typically a hot-applied, highly polymer-modified liquid asphalt membrane that is applied prior to paving, directly beneath the future location of the longitudinal joint. As the hot asphalt mat is paved, the heat causes the highly polymer-modified membrane to migrate upward into the mat at the joint, filling air voids and reducing permeability from the bottom up.

Another relatively recent innovation with potential to reduce longitudinal joint deterioration substantially is the use of rapid-penetrating emulsions (RPEs). RPEs are asphalt emulsions specially formulated to penetrate quickly into low-density asphalt pavements, where they fill interconnected air voids, reduce permeability, and fill small cracks. RPE products can be applied using distributor trucks equipped with fog nozzles, either immediately after construction or later in the pavement's service life. Application rates can be adjusted based on permeability, texture, amount of air voids, and pavement age. Therefore, both VRAM and RPE technologies have the potential to improve pavement performance at longitudinal joints.

This study examined VRAM, RPE, and other approaches to reducing the deterioration of longitudinal joints based on experiences and field trials on highway pavements. The project deliverables are presented in three volumes:

- Volume 1—A literature review of VRAM, RPE, and other techniques to improve longitudinal joint performance, as well as a literature review of longitudinal joint maintenance for airfield pavements.
- Volume 2—Project reports on inspections of existing VRAM installations and documentation of new applications of VRAM and RPE at airports.
- Volume 3—A *Best Practices Manual for Longitudinal Joint Maintenance*.

This document corresponds to Volume 2.

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List of Acronyms and Abbreviations

AADT	Annual average daily traffic
AC	Advisory Circular
APMS	Airport Pavement Management System
ASTM	ASTM International
CRSC	Crack relief seal coat
DOT	Department of Transportation
FAA	Federal Aviation Administration
IDOT	Illinois Department of Transportation
L&T	Longitudinal and transverse
LJS	Longitudinal joint sealant
NAPA	National Asphalt Pavement Association
NCAT	National Center for Asphalt Technology
PCI	Pavement Condition Index
RPE	Rapid-penetrating emulsion
VRAM	Void-reducing asphalt membrane

Introduction

Volume 2 of this report on *Improving Performance of Longitudinal Joints in Airfield Asphalt Pavements* describes site inspections conducted for existing projects with void reducing membrane (VRAM) installations to assess their performance, as well as site inspections of new projects installing VRAM and rapid-penetrating emulsion (RPE) to document their application. This report presents project summaries for each of the sites inspected.

Site Inspections for Existing VRAM Projects

Site Inspection Locations

As part of this research study, six existing field sites were selected to assess the performance of longitudinal joints treated with VRAM. These sites consisted of three airport pavements and three roadway pavements. Table 1 summarizes the project locations, the construction date, the control joint type, and the dates the research team conducted the inspections.

Table 1. Inspections of Existing VRAM Projects

Project #	Location	Date Constructed	Control Joint Type	Inspection Date
1	U.S. Highway 51, Decatur, IL	2002	Butt	Oct. 3, 2022
2	Iowa Highway 13, Marion, IA	2016	Unknown	Nov. 28, 2022
3	Iowa Highway 57, West of Ackley, IA	2016	Butt or notched wedge	May 25, 2023
4	Pekin Municipal Airport, IL	June 2019	Cutback	June 5, 2023
5	Decatur Airport, IL	May 2020	None	June 12, 2023
6	Coles County Memorial Airport, IL	June 2021	Cutback	June 7, 2023

Site Visit Plan

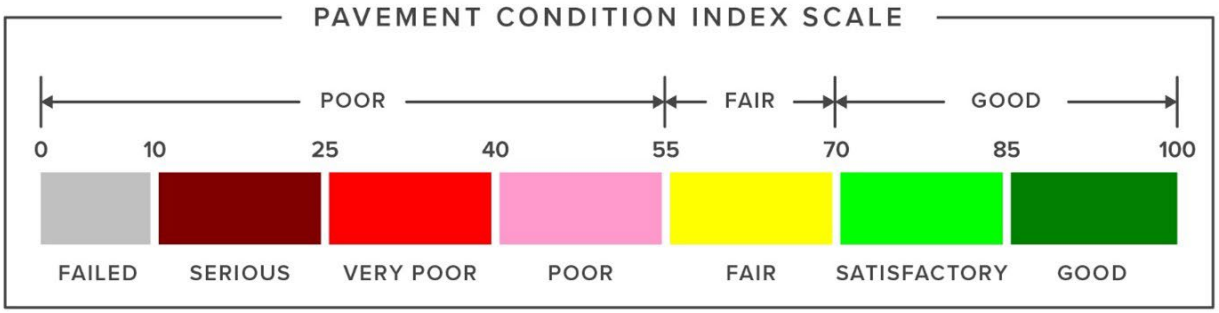
To assess the performance of treated longitudinal joints, a visual inspection of the condition, relative density testing, and field permeability testing were conducted.

Visual Inspection

The visual inspections were performed in accordance with ASTM D5340 (latest version), *Standard Test Method for Airport Pavement Condition Index (PCI) Surveys*. Although several sites are roadways, the airport test method was used for these sites for consistency, with minor modifications as discussed later in this report. The PCI rating is a numerical measure of the existing condition of the pavement based on observed surface distresses. The results provide an indication of the pavement's structural integrity and functional capabilities but serve only as an indirect indicator of the pavement's overall condition, as it only examines the surface. Nevertheless, the PCI provides an objective basis for determining maintenance and rehabilitation needs, as well as for establishing priorities in the face of resource constraints. Furthermore, the results of repeated PCI monitoring over time can be used to assess the rate of deterioration and estimate when certain rehabilitation measures may be needed.

The PCI scale, as shown in Figure 1, ranges from a value of 0 (representing a pavement in a completely failed condition) to a value of 100 (representing a pavement with no distress). In general terms, pavements with a PCI above 70 that are not exhibiting significant amounts of

load-related distress will benefit from preventive maintenance actions, such as joint and crack sealing and patching. Pavements with a PCI between 40 and 70 are more likely candidates for major rehabilitation activities, such as milling and overlay or slab repairs. Often, when the PCI is less than 40, reconstruction is the most viable alternative due to substantial deterioration of the pavement structure.



Source: U.S. Army Corps of Engineers

Figure 1. General PCI Rating Scale

Although PCI ratings can be used as a general guideline for identifying the repair type, examining the individual distresses measured during the inspection is often more useful in assessing the cause(s) of deterioration. The PCI procedure divides distresses into three categories based on the expected cause of the distress. By knowing the cause(s) of the pavement deterioration, appropriate repair and rehabilitation alternatives can be identified.

The three categories of distress types used are load-related, climate-related, and other distresses (which include distresses not directly related to load or climate). Load-related distresses are defined as being caused by aircraft (or vehicle) traffic and may provide an indication of a structural deficiency. Climate-related distresses often signify the presence of aged or environment-susceptible material (or both).

The distress types for asphalt-surfaced pavement are categorized in Table 2, as defined in the *PAVER™ Distress Identification Manual* [1].

Table 2. Distress Types by Pavement Distress Category [1]

Pavement Type	Pavement Distress Category[1]		
	Load-Related	Climate-Related	Other
Asphalt-surfaced	• Alligator (fatigue) cracking • Rutting	• Block cracking • Joint reflection cracking • Longitudinal and transverse (L&T) cracking • Patching • Raveling • Weathering	• Bleeding • Corrugation • Depression • Jet-blast erosion • Oil spill damage • Polished aggregate • Shoving • Slippage cracking • Swelling

[1]As defined in PAVER

For this project, each longitudinal joint survey section was assessed for a 4-ft (1.2-m) width (2 ft [.6 m] to each side) along the joint. Longitudinal joint distress is not specifically defined in the standard method, so the PCI rating for longitudinal and transverse (L&T) cracking was modified to better differentiate low-severity conditions (see Table 3). The length of the joint rated at each severity level was measured, with different severities often occurring along the joint in the survey section.

Table 3. Modification to ASTM Longitudinal and Transverse Cracking Severity

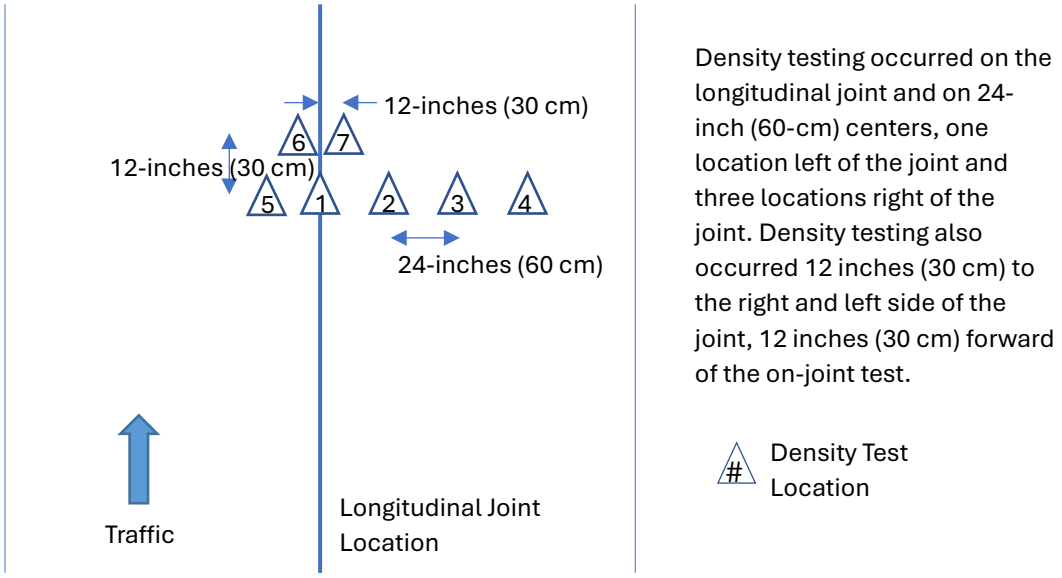
ASTM Severity	ASTM Description	Modified Severity	Modified Description
Low	Filled or non-filled, no to light spalling. If non-filled, <1/4 inch (6 mm) width; if filled, any width, good condition seal.	Low-1	Tight with no (or very little) noticeable joint.
		Low-2	Tight but noticeable joint.
		Low-3	See ASTM definition.

Other distresses within the 4-ft (1.2-m) band centered over the longitudinal joint were rated in accordance with the ASTM airport procedure. If roadway distresses were present that did not fall within the airport ratings (such as potholes), those ratings were used.

Relative Density Testing

Relative density testing was conducted using an InstroTek® NoNuke™ density gauge. The device meets the requirements of ASTM D7113 and AASHTO T343. Because maximum densities for the project-specific mixtures were unavailable, the equipment's default maximum density of 145 lb/ft^3 (2,322 kg/m^3) was used for project testing. Density readings were obtained to determine the relative density between joint and mat locations. The data are only intended for site-specific comparison because laboratory testing was not used to establish a correlation.

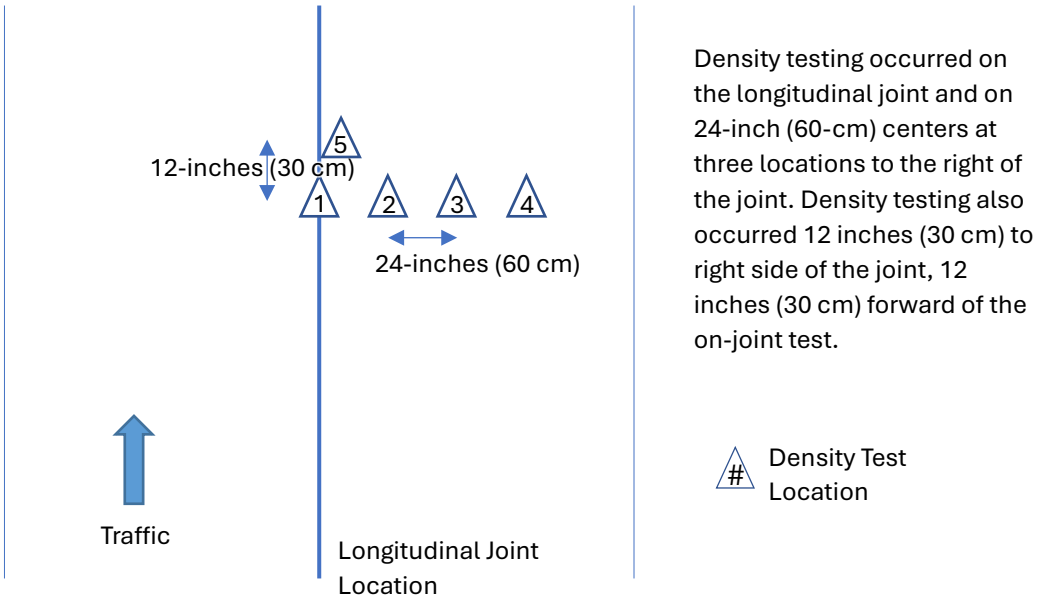
Density test locations depended on the site (airport versus roadway) due to traffic control and worker safety. For airport sites, seven density tests were obtained within each survey section, as presented in Figure 2.



Source: Iowa State University

Figure 2. Airport Density Testing Layout

For roadways, five density tests were performed within each survey section, as presented in Figure 3, based on the assumption that traffic control has closed the lane to the right of the longitudinal joint location.



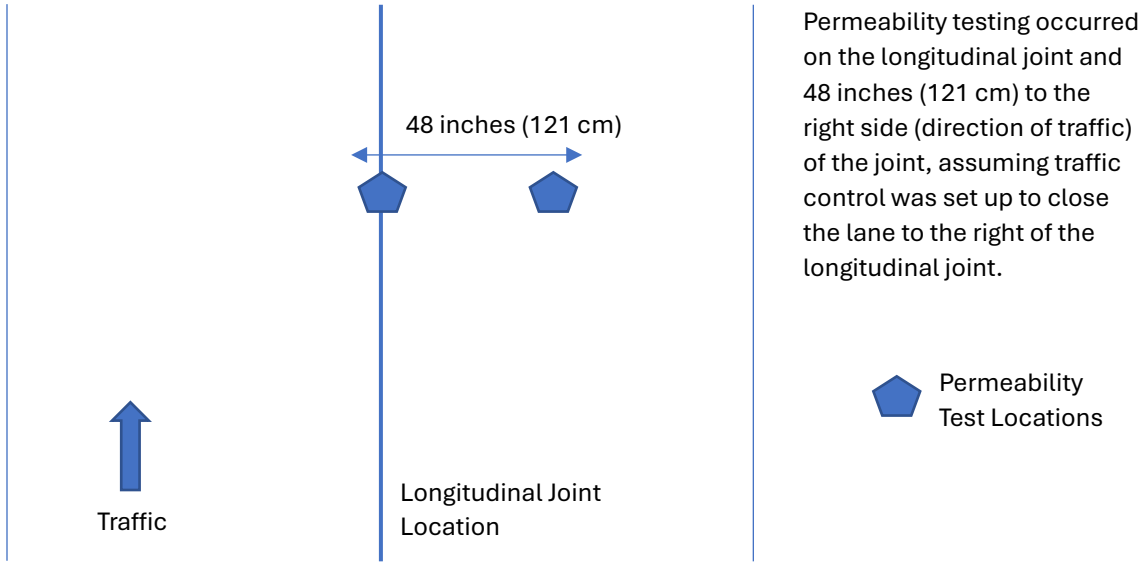
Source: Iowa State University

Figure 3. Roadway Density Testing Layout

Field Permeability Testing

Permeability testing was performed using a falling-head permeameter device developed by the Florida Department of Transportation (DOT).

Two permeability tests were collected in each survey section, as shown in Figure 4.



Source: Iowa State University

Figure 4. Field Permeability Testing Layout

The following sections summarize each of the six existing VRAM project site inspections.

Site Inspection—U.S. Highway 51 in Decatur, IL

Project Description

An asphalt longitudinal joint test section was constructed on U.S. Highway 51 (US-51) near Decatur, IL, for the Illinois DOT (IDOT) in September 2002. The monitoring site included test sections with VRAM—or longitudinal joint sealant (LJS), as referred to by IDOT—applied prior to the surface course placement. The site also included other joint treatment methods and control sections. Two VRAM test sections (see Figure 5) and two control sections were inspected for this research project on Oct. 3, 2022. The two VRAM sections consisted of applications of VRAM with a 12-inch (30-cm) and 18-inch (45-cm) width. Each section was approximately 100 ft (30 m) long.



Original Photo: © 2023 Google® (see Acknowledgments section). Image modified by APTech to identify field test locations.

Figure 5. Overview of US-51 Project Area

Construction Records

Construction plans and specifications were not available for review. Based on available information, construction consisted of milling the existing pavement, placing the lower asphalt lift, applying the VRAM, then placing the surface asphalt lift, as shown in Figure 6. Available documentation does not appear to indicate an application rate for this project.



Source: Illinois Department of Transportation

Figure 6. Placing Surface Asphalt over Applied VRAM on US-51 [2]

Visual Inspection

Distresses were assessed for type and severity according to the PCI methodology. A PCI value was determined for the joint based on the collected distress data. However, the survey is based on the length of the joint using an approximate 4-ft (1.2-m) width. This area does not correspond to a typical PCI sample unit size. The PCI deducts are calculated based on the density of the distresses, and by having a relatively small area and a high density of distress, the deducts are very high. Therefore, the associated PCI values are only a relative comparison between these specific test sections. A summary of distresses observed along each joint segment is included in Table 4.

Table 4. Relative PCI Ratings for the Test Sections

Section	2022 Relative PCI[1]	Distress	Severity	Quantity
12-inch (30-cm) VRAM	25	Alligator Cracking	Medium	19 ft² (2 m²)
		L&T Cracking	Low-3	113 ft (34 m)
		L&T Cracking	Low-1	88 ft (26 m)
		L&T Cracking	Medium	15 ft (4 m)
		Patch	Medium	12 ft² (1 m²)
		Weathering	Medium	388 ft² (36 m²)
Control Section 1	4	Alligator Cracking	Medium	105 ft² (10 m²)
		L&T Cracking	Low-3	22 ft (6 m)
		L&T Cracking	Medium	68 ft (20 m)
		L&T Cracking	High	38 ft (11 m)
		Raveling	High	5 ft² (0.4 m²)
		Weathering	Medium	395 ft² (37 m²)
18-inch (45-cm) VRAM	17	Alligator Cracking	Medium	15 ft² (1.4 m²)
		L&T Cracking	Low-3	185 ft (56 m)
		L&T Cracking	Low-1	100 ft (30 m)
		L&T Cracking	Medium	45 ft (13 m)
		Raveling	High	2 ft² (0.2 m²)
		Weathering	Medium	398 ft² (37 m²)
Control Section 2	10	Alligator Cracking	Medium	262 ft² (24 m²)
		L&T Cracking	Low-3	29 ft (8 m)
		L&T Cracking	Medium	78 ft (23 m)
		Patch	Low	25 ft² (2 m²)
		Patch	Medium	25 ft² (2 m²)
		Patch	High	100 ft² (9 m²)
		Raveling	High	10 ft² (0.9 m²)
		Weathering	Medium	390 ft² (36 m²)

[1]Based on a 4-ft (1.2-m)-wide by 100-ft (30-m)-long survey sample.

12-inch (30-cm) VRAM

The 12-inch (30-cm) VRAM is the southernmost section within the US-51 monitoring section. As shown in Figure 7, the majority of the longitudinal joint appeared to be sealed with no or minimal opening and was rated as low-severity longitudinal cracking. Note the joint to the left of the VRAM is from pavement widening. The crack sealant that was applied overlapped some of the surface (i.e., it was not recessed). Portions of the joint were patched (see Figure 8) and there was a small area of alligator (or fatigue) cracking (see Figure 9). The PCI of this section was 25.



Source: APTech

Figure 7. Overview of 12-inch (30-cm) VRAM Section



Source: APTech

Figure 8. Patching Along 12-inch (30-cm) J-Band Section



Source: Iowa State University

Figure 9. Area of Fatigue Cracking Within 12-inch (30-cm) J-Band Section

Control Section 1

Control section 1 was directly north of the 12-inch (30-cm) J-Band section. The longitudinal joint was previously sealed (see Figure 10); however, the severity of longitudinal crack varied throughout the length of the section, including low-, medium-, and high-severity areas. Medium-severity alligator cracking (see Figure 11) and high-severity raveling were also observed around the longitudinal joint. The PCI of this joint segment was 4.



Source: Iowa State University

Figure 10. Overview of Control Section 1



Source: Iowa State University

Figure 11. Alligator Cracking Along Control Section 1

18-inch (45-cm) VRAM

The 18-inch (45-cm) VRAM section was located approximately 600 ft (182 m) north of control section 1. Similar to the 12-inch (30-cm) J-Band section, the longitudinal joint was previously sealed with minimal joint opening; therefore, most of the cracking recorded on this section was at low severity (see Figure 12 and Figure 13). Other distresses observed in this joint segment included medium-severity L&T cracking, medium-severity alligator cracking, and a small amount of high-severity raveling. The PCI of this joint segment was 17.



Source: Iowa State University

Figure 12. Overview of 18-inch (45-cm) VRAM Section



Source: Iowa State University

Figure 13. Close-Up of Longitudinal Cracking in 18-inch (45-cm) VRAM Section

Control Section 2

Control section 2 was directly north of the 18-inch (45-cm) VRAM section. As shown in Figure 14, the longitudinal joint was patched along the entire length of the section (it appeared to be primarily cold patching material), with most areas showing high levels of deterioration (see Figure 15). Distresses in this section included low- and medium-severity L&T cracking, medium-severity alligator cracking, and high-severity raveling (see Figure 16). The PCI of this section was 10.



Source: Iowa State University

Figure 14. Overview of Control Section 2



Source: Iowa State University

Figure 15. Patching Along Control Section 2



Source: Iowa State University

Figure 16. Raveling Along Control Section 2

The average PCI for the VRAM sections was 21, while the average PCI for the control sections was 7. After 20 years of service, the VRAM joints have performed substantially better for this test site than the control joints.

Relative Density Testing

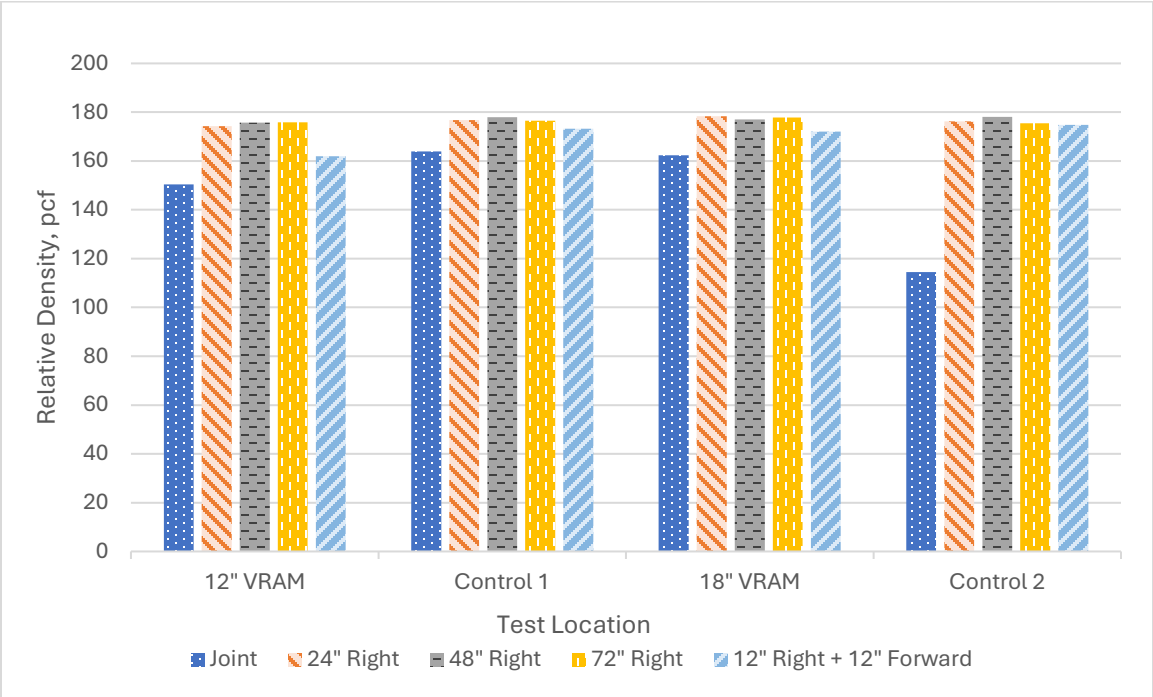
Density testing was conducted, but the reliability of the results is uncertain due to the deteriorated condition of the joints. Results are summarized in Table 5 and Figure 17. As expected, the joint densities were lower than the mat densities. In comparison to control section 2, the VRAM-treated joints had greater density. However, control section 1 had a higher average density than the other joint locations.

Table 5. Summary of Density Testing

Test Location	Average Relative Density, pcf[1]				Density Ratio	
	12-inch (30-cm) VRAM	Control 1	18-inch (45-cm) VRAM	Control 2	12-inch (30-cm) VRAM/ Control 1	18-inch (45-cm) VRAM/ Control 2
Joint	150.4	163.9	162.3	114.5[2]	91.8%	141.7%
24 inches right (61 cm)	174.3	176.8	178.3	176.2	98.6%	101.2%
48 inches (121 cm) right	175.7	177.9	177.1	178.1	98.8%	99.4%
72 inches (183 cm) right	175.8	176.5	177.8	175.5	99.6%	101.3%
12 inches (30 cm) right + 12 inches (30 cm) forward	162.0	173.3	172.0	174.8	93.5%	98.4%

[1]pcf = pounds per cubic foot.

[2]Not believed to be representative; equipment was not in solid contact with pavement surface due to deterioration.



Source: Iowa State University

Figure 17. Summary of Density Testing

Field Permeability Testing

Permeability testing was not possible on the control sections due to the inability to obtain a seal under the testing plate because of the extensive joint deterioration. Therefore, relative permeability measurements are not available for this site.

Coring

Coring was performed in each of the identified survey sections. The core locations correspond with the permeability test locations, although field permeability testing was not possible in the control sections. Two cores were retrieved from each of the locations: one on the longitudinal joint and one located 48 inches (121 cm) to the right, as shown in Figure 18.



Source: Iowa State University

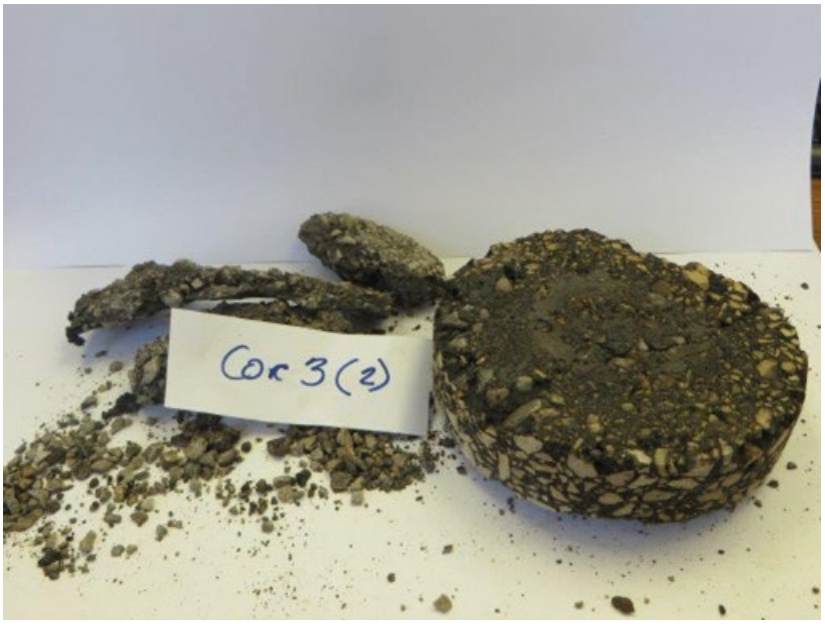
Figure 18. Typical Core Location Layout

Cores were generally in poor condition. Locations with VRAM were typically retrieved intact, with the two asphalt lifts bonded, although the surface and lower lifts were deteriorated, as shown in Figure 19. A heavy amount of VRAM material was observed in the intact cores that could not be retrieved from the control sections. Pieces of the cores are shown in Figure 20.



Source: Iowa State University

Figure 19. Cores Retrieved from VRAM Sections



Source: APTech

Figure 20. Pieces of a Core Retrieved from the Control Section

In general, while substantial joint deterioration was observed for sections with and without VRAM, the cores from sections with VRAM were more intact. Because of the poor condition of the cores, no laboratory testing was conducted for this project site.

Summary of U.S. Highway 51 Project

Although all of the longitudinal joints have deteriorated through 20 years of service, the joints treated with VRAM visually performed better than the control butt joint, with VRAM joints having PCIs of 25 and 17 compared to PCIs of 4 and 10 for butt joint control sections. The VRAM sections had much less cracking along the longitudinal joint, with L&T cracks forming roughly at the edges of the VRAM application. The untreated joints had much more patching along the joints, with control section 2 patched the entire joint length.

Density testing was inconclusive. The density at the control section 1 joint was higher than both the VRAM sections and control section 2. The extent of cracking along the joints likely influenced the density results obtained. Although deterioration was observed in all of the cores, those retrieved from joints with VRAM treatment were mostly intact, in contrast to pieces of cores obtained from control butt joints.

Since a 2016 resurfacing project, Iowa DOT has routed and sealed all the longitudinal joints on this project as part of its routine maintenance program. This has obscured possible differences in the performance of the longitudinal joints for the VRAM section and the control section.

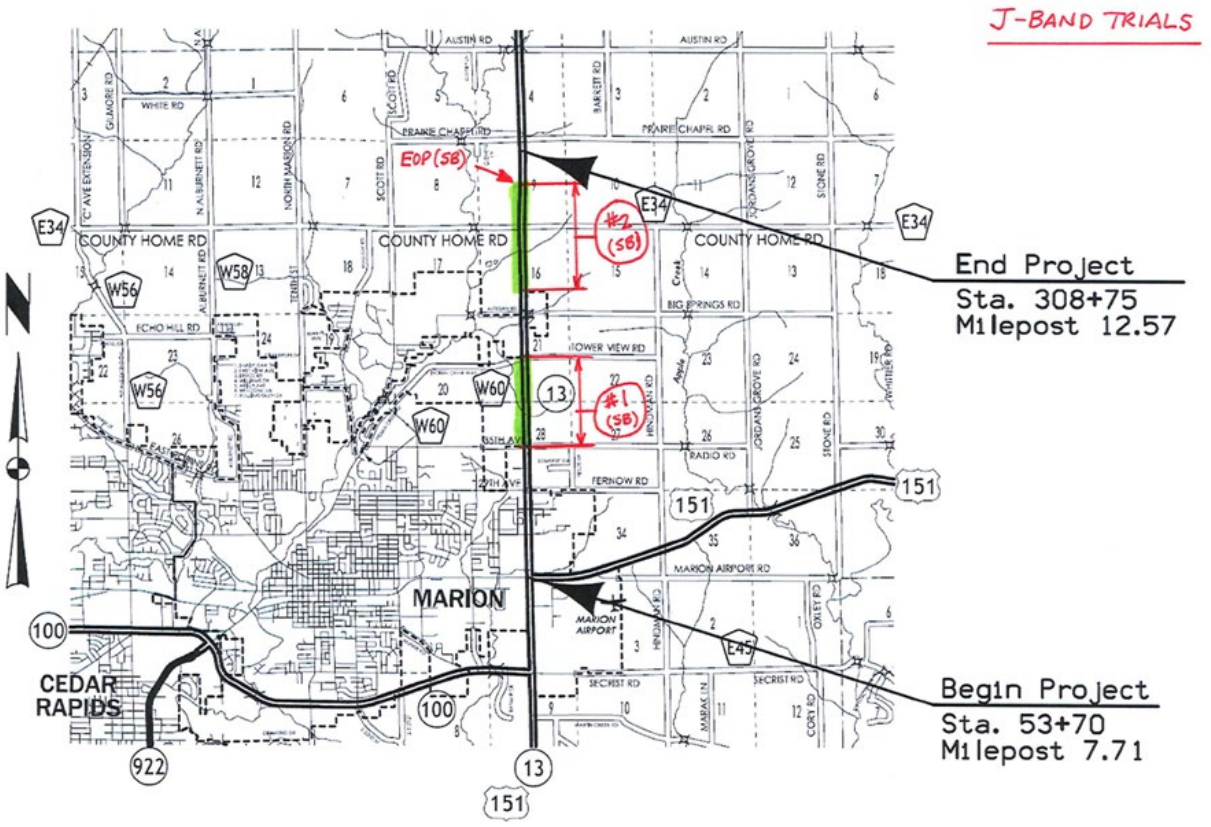
The density measurements show a trend consistent with the hypothesis that the VRAM reduces the voids in the centerline joint. However, the 1.80 lb/linear ft (2.68 kg/m) application rate had a lower relative density increase than the 1.47 lb/linear ft (2.19 kg/m) application rate.

Obtaining reliable measurements using the field permeameter was not possible because deterioration along the longitudinal joint prevented a complete seal with the pavement, allowing water to flow laterally along the joint.

Site Inspection—Iowa Highway 13 in Marion, IA

Project Description

Iowa Highway 13 is a four-lane divided highway with an annual average daily traffic (AADT) of 8,400. The pavement was resurfaced in July 2016. As part of that rehabilitation project, two portions of the southbound tract were constructed with VRAM applied to the longitudinal joint using a butt joint. Segment number 1 was applied at an application rate of 1.47 lb/linear ft (2.19 kg/m) and 18 inches (45 cm) wide, while segment number 2 was applied at an application rate of 1.80 lb/linear ft (2.68 kg/m) and 18 inches (45 cm) wide. A control section was selected in the northbound lanes directly across from segment number 2. An overview of the application locations is provided in Figure 21.



Source: APTech

Figure 21. VRAM Section Locations

Pavement Condition and Readings

Since the 2016 resurfacing project, Iowa DOT has routed and sealed all of the longitudinal joints on this project as part of its routine maintenance program. This has obscured possible differences in the performance of the longitudinal joints for the VRAM section and the control section.

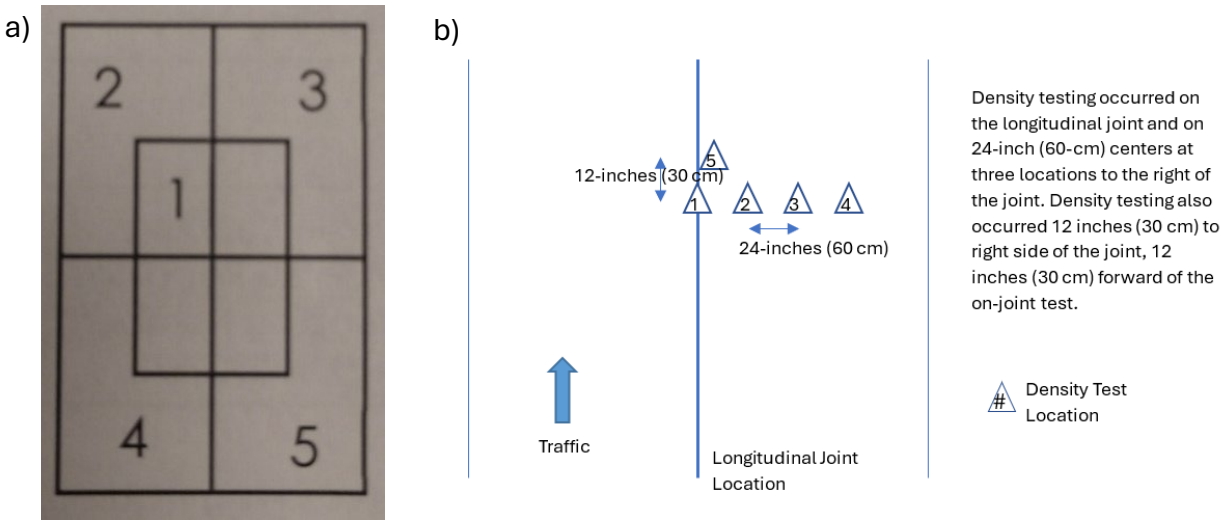
Onsite visits in November 2022 and April 2023 collected NoNuke gauge density readings and acquired cores. However, these visits were unable to obtain accurate field permeability measurements because deterioration along the longitudinal joint prevented a complete seal with the pavement, causing much of the water to leak out at the base of the permeameter and rendering the test meaningless. Figure 22 shows the deterioration along the longitudinal joint laterally along the pavement surface and an example of the sealed centerline joint.



Source: Iowa State University

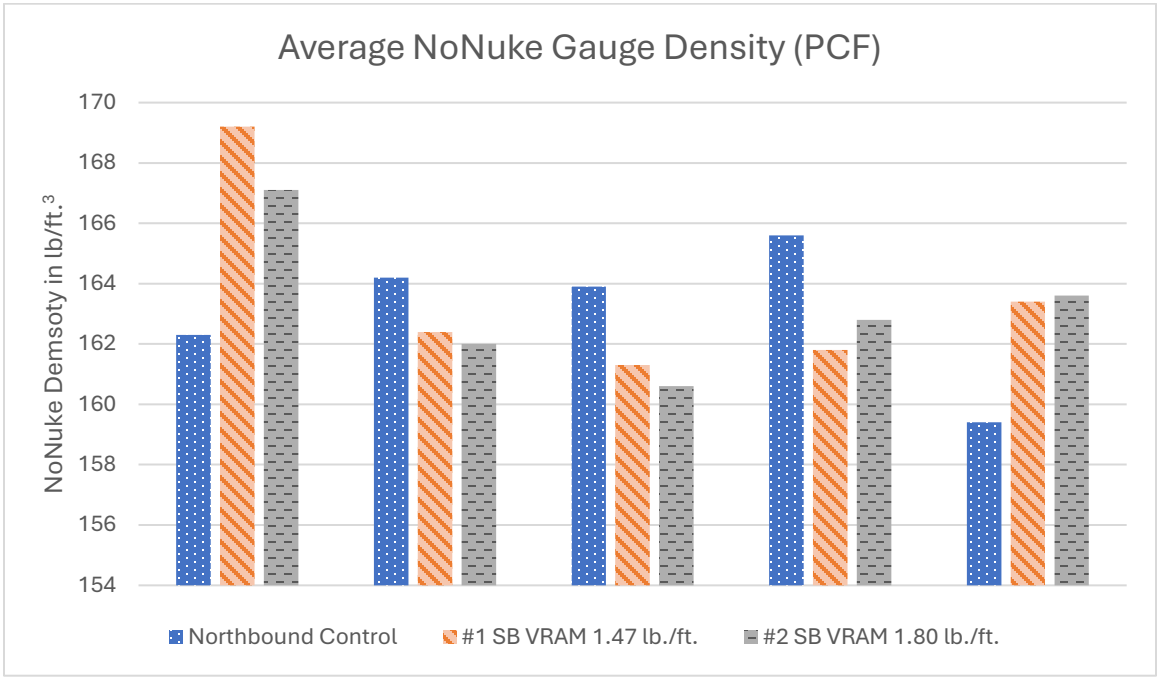
Figure 22. Example of Permeameter Along a Centerline Joint (left) and of a Sealed Centerline Joint (right)

A NoNuke density gauge was used to measure the relative density of the pavement in the single point pattern shown in Figure 23a, and a roadway pattern is shown in Figure 23b. Figure 23a is the NoNuke gauge testing pattern. At each coring location, five readings are taken per point using the pattern shown in Figure 23a at the locations shown by the triangles in Figure 23b. The resulting measurements are detailed in Figure 24 and Table 6.



Source: Iowa State University

Figure 23. (a) Single Point Density Pattern; (b) Roadway Density Layout



Source: Iowa State University

Figure 24. NoNuke Gauge Readings for Iowa Highway 13

Table 6. NoNuke Gauge Readings for Iowa Highway 13 (lb/ft^3)

Testing Location	1	2	3	4	5
Northbound Control	162.3	164.2	163.9	165.6	159.4
#1 SB VRAM 1.47 lb/ft	169.2	162.4	161.3	161.8	163.4
#2 SB VRAM 1.80 lb/ft	167.1	162.0	160.6	162.8	163.6

Note: SB = southbound.

Due to the difficulty of obtaining intact cores from the centerline joint, cores were primarily drilled from 3 to 4 inches (7 to 10 cm) off the longitudinal joint at the same point as the NoNuke density readings along all three test segments. A core directly on the longitudinal joint is pictured in Figure 25.



Source: Iowa State University

Figure 25. Centerline Joint Condition

Summary Iowa Highway 13

Since the 2016 resurfacing project, Iowa DOT has routed and sealed all the longitudinal joints on this project as part of its routine maintenance program. This has obscured possible differences in the performance of the longitudinal joints for the VRAM section and the control section.

The density measurements show a trend consistent with the hypothesis that the VRAM reduces the voids in the centerline joint. However, the 1.80 lb/linear ft (2.68 kg/m) application rate had a lower relative density increase than the 1.47 lb/linear ft (2.19 kg/m) application rate.

Obtaining reliable measurements using the field permeameter was not possible because deterioration along the longitudinal joint prevented a complete seal with the pavement, allowing water to flow laterally along the joint.

Site Inspection—Iowa Highway 57 West of Ackley, IA

Project Description

Iowa Highway 57 is a two-lane highway with an AADT of 1,770. The pavement was resurfaced in 2016, with VRAM applied to the longitudinal joint using a butt joint. VRAM was applied at an application rate of 1.44 lb/linear ft (2.14 kg/m).

Maintenance and safety activities since construction included crack sealing of the longitudinal joint and the addition of a centerline rumble strip (see Figure 26). Therefore, it was not possible to evaluate possible differences in the longitudinal joints for the VRAM section and the control section.



Source: Iowa State University

Figure 26. Highway 57 with Sealed Cracks and Rumble Strip

Pavement Condition and Readings

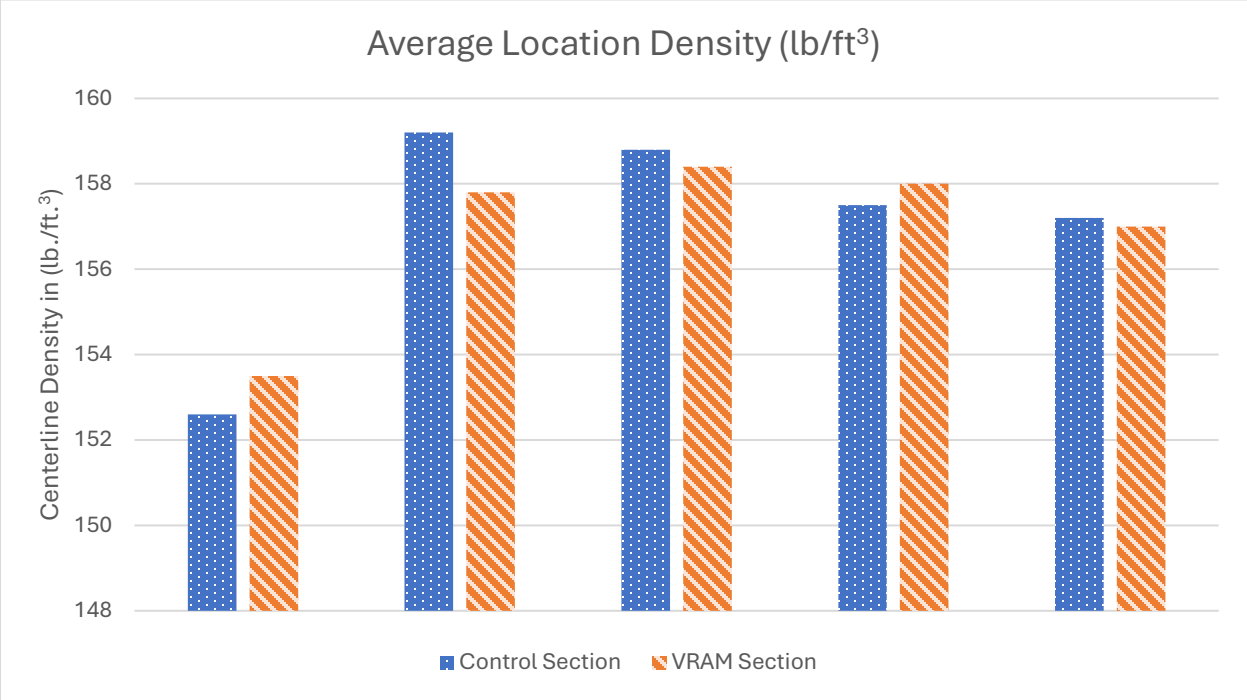
An onsite visit in May 2023 collected NoNuke gauge density readings and acquired cores from both the VRAM section and the adjacent section without VRAM. However, it was not possible to obtain accurate longitudinal joint field permeability measurements. Deterioration along the longitudinal joint (see Figure 27) prevented a complete seal with the pavement, allowing water to flow laterally along the pavement's surface.



Source: Iowa State University

Figure 27. Deterioration Along a Centerline Joint

A NoNuke density gauge was used to measure the relative density of the pavement in the single point pattern, as was shown in Figure 23a, using the roadway pattern that was shown in Figure 23b. The resulting measurements are detailed in Figure 28 and Table 7.



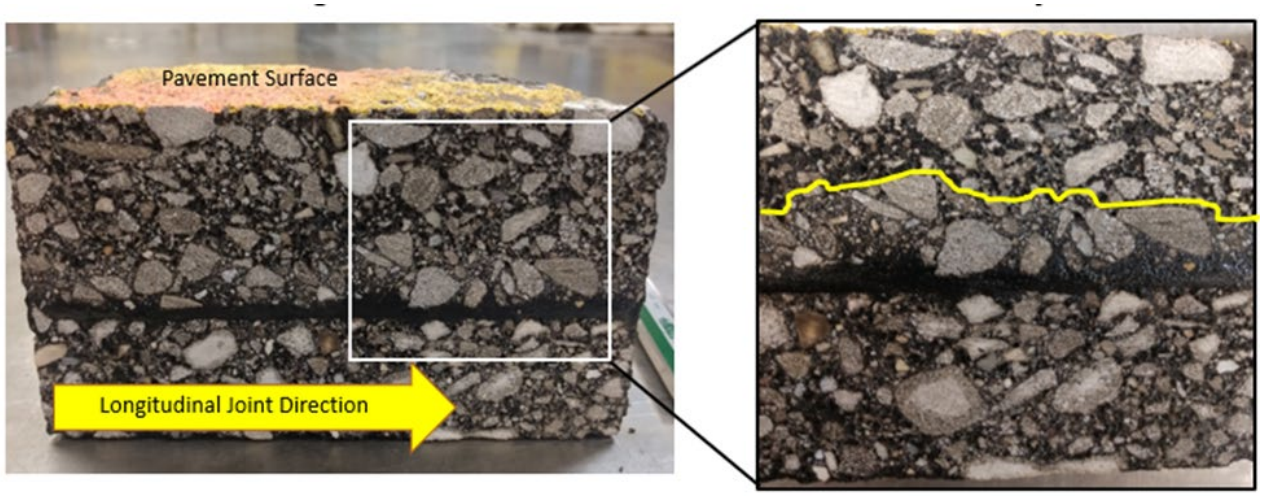
Source: Iowa State University

Figure 28. NoNuke Gauge Readings for Highway 57

Table 7. NoNuke Gauge Readings for Highway 57 (lb/ft³)

Testing Position	1	2	3	4	5
Control Section	152.6	159.2	158.8	157.5	157.2
VRAM Section	153.5	157.8	158.4	158.0	157.0

A bisection of a core from the longitudinal joint is pictured in Figure 29. This core was bisected parallel to the longitudinal joint, and a visually suspected VRAM boundary was highlighted to show the apparent migration of the material. Additional intact core samples were sent to Auburn University for further analysis.



Source: Iowa State University

Figure 29. Bisection of Core with VRAM Boundary Highlighted

Summary of Iowa Highway 57

Pavement maintenance and safety activities since the application of VRAM included crack sealing of the longitudinal joint and the addition of a centerline rumble strip. Therefore, it was not possible to assess differences in the performance of the longitudinal joints for the VRAM section and the control section.

The NoNuke gauge density measurements show a trend that contradicts the hypothesis that VRAM increases the density at the longitudinal joint. This could be an artifact of the centerline rumble strip grinding depositing material that interferes with the NoNuke gauge, or it could be due to the centerline joint sealant density reducing the density of the core. However, from Figure 29, it appears that VRAM material penetrates the voids in the bottom part of the overlay.

Obtaining reliable measurements using the field permeameter was not possible due to deterioration along the longitudinal joint that prevented a seal between the permeameter and the pavement surface, allowing water to flow laterally along the surface.

Site Inspection—Pekin Municipal Airport, IL

Project Description

Runway 9-27 at Pekin Municipal Airport, located south of Pekin, IL, was rehabilitated in 2019. The runway is 5,000 ft (1,524 m) long by 75 ft (22 m) wide and serves general aviation traffic. The existing runway pavement was asphalt over an aggregate base on the prepared subgrade. The runway rehabilitation project consisted of milling the existing asphalt surface and placing a new asphalt surface at the west end of the runway and

reconstructing the asphalt surface for the remainder of the runway. This appears to be the earliest airport application of VRAM [3]. An overview of the Runway 9-27 rehabilitation area is provided in Figure 30.



Source: Tazewell County GIS Portal, September 19, 2022

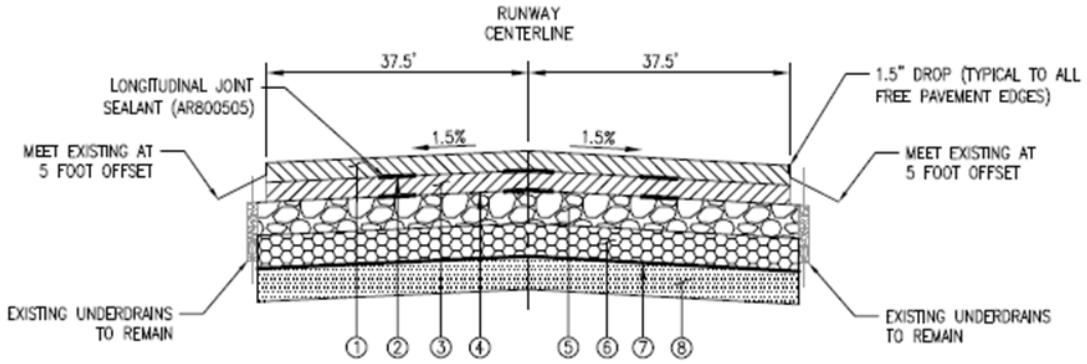
Figure 30. Overview of Pekin Municipal Airport and Project Area

Airport Records

Typical cross sections for the 2019 rehabilitation are provided in Figure 31. The 1,200-ft (366-m) section at the west end (Runway 9 approach) consisted of a 2-inch (50-mm) mill and overlay (Section B-B in Figure 31), while the remaining 3,800 ft (1,158 m) were milled 9.5 inches (241 mm) (full-depth removal) and the surface reconstructed (Section A-A in Figure 31). VRAM (LJS) was applied to the centerline joint and longitudinal paving joints on the left and right of the centerline in both sections. The paving lane width was 18.75 ft (5.72 m). The runway surface was not grooved.

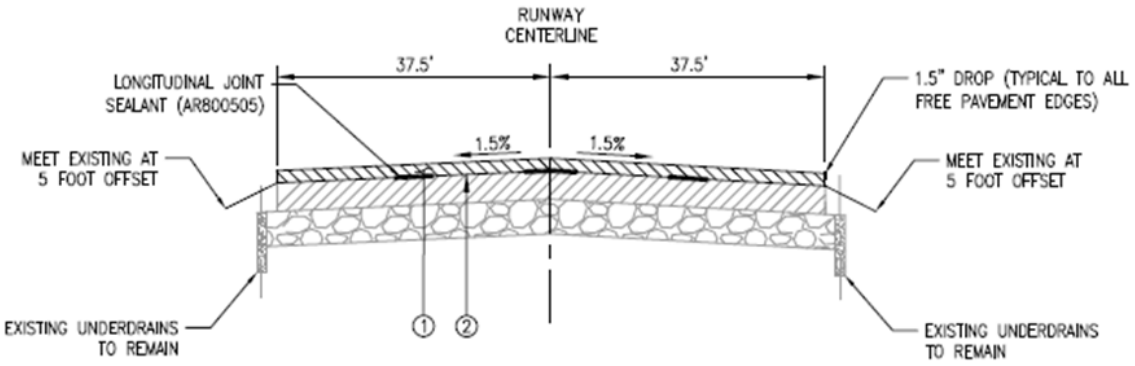
Construction specifications for the project included the following:

- Item 800505 Longitudinal Joint Sealant.
- Item 401614 Bituminous Surface Course—Method II, Superpave.
- Item 403614 Bituminous Base Course—Method II, Superpave.



Typical Section A-A, Runway 9-27
(Section Shown Looking East)

1) Proposed 2-inch (5-cm) bituminous surface course, item AR401614.
2) Proposed bituminous tack coat, item AR603510.
3) Proposed 2-inch (5-cm) bituminous base course, item AR4031614.
4) Proposed bituminous prime coat, item AR602510.
5) Proposed 4-inch (10-cm) aggregate base course, item AR209604.
6) Proposed 6-inch (15-cm) granular drainage subbase, item AR154606.
7) Proposed separation fabric, item AR156513.
8) Proposed 7.5-inch (19-cm) millings subbase, AR800509.



Typical Section B-B, Runway 9-27
(Section Shown Looking East)

1) Proposed 2-inch (5-cm) nominal depth milling and 2-inch (5-cm) bituminous surface course, items AR401650 and AR401614.
2) Proposed bituminous tack coat, item AR603510.

Source: Hanson Professional Services, Inc., 2018

Figure 31. Left Runway 9-27 Rehabilitation Typical Cross Sections [4]

The VRAM material was applied in an 18-inch (45-cm)-wide strip at all longitudinal joint locations using truck application (see Figure 32). VRAM was applied after the tack coat application. The application rate during construction was 0.95 lb/linear ft (3.10 kg/m^2) [3].

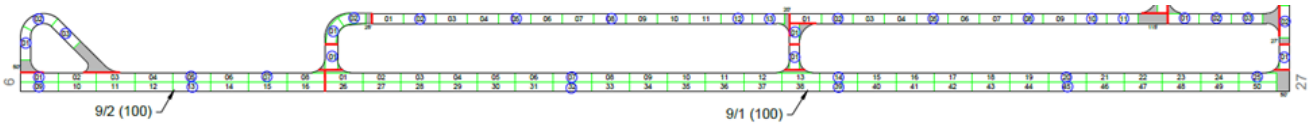


Source: Asphalt Materials, Inc., 2019

Figure 32. Application of VRAM in Section 2 of Runway 9-27 [3]

Pekin Municipal Airport is included in the IDOT Division of Aeronautics' Statewide Airport Pavement Management System (APMS). As part of the Illinois APMS, APTech has conducted visual condition surveys at this airport over many years. The included pavement area corresponds to the following sections from the Illinois APMS (see Figure 33):

- Runway 9-27, Section 1 (surface reconstruction).
- Runway 9-27, Section 2 (overlay).



Source: APTech, 2021

Figure 33. Airport Pavement Management Plan Network Definition Map [5]

Conditions prior to the rehabilitation work (see Figure 34 and Figure 35) show the paving lane joints primarily as having low- to medium-severity L&T cracks, with many areas of the joints having been sealed. The airport was also surveyed shortly after the rehabilitation of

the runway, and paving joints were difficult to discern in many locations, as shown in Figure 36 and Figure 37.



Source: APTech

Figure 34. Runway 9-27, Section 1, 2017, Overview (Looking East)



Source: APTech

Figure 35. Runway 9-27, Section 2, 2017, Overview (Looking East)



Source: APTech

Figure 36. Runway 9-27, Section 1, 2020, Overview (Looking West)



Source: APTech

Figure 37. Runway 9-27, Section 2, 2020, Overview (Looking East)

Site Inspection

Runway 9-27 was inspected as part of this project on June 5, 2023. The pavement surface was 4 years old at the time of the survey. Three, 100-ft (30-m) joint sample units along the longitudinal joints were selected from each section. Among the three sample units in each section, one sample unit was selected at the center longitudinal joint and the other two sample units were selected from either side of the center longitudinal joint.

Runway 9-27, Section 1 (Surface Reconstruction)

While the majority of the longitudinal joints appeared to be very tight, they were still visible. Photographs of the joints in Runway 9-27, section 1, are presented in Figure 38 through Figure 41. These joints were rated primarily as low-severity (Low-2 in modified ratings) L&T cracking. A small portion of the longitudinal joint in sample unit 3 (north longitudinal joint) had a visible crack less than 1/4 inch (0.6 cm) wide and was rated as low-severity (Low-3) L&T cracking. Additionally, all surveyed sample units displayed low-severity weathering. Summarized distress data are presented in Table 8.



Source: APTech

Figure 38. Runway 9-27, Section 1, 2023, Overview (Looking East)



Source: APTech

Figure 39. Runway 9-27, Section 1, 2023, Paving Lane Joint (Low-2 Severity)



Source: APTech

Figure 40. Runway 9-27, Section 1, 2023, Paving Lane Joint (Low-3 Severity)



Source: APTech

Figure 41. Runway 9-27, Section 1, 2023, Weathering (Low Severity)

Table 8. Summary of Maintenance Techniques for Longitudinal Joints

Section	Sample Unit	Location	Distress	Severity	Quantity
9/1	01	Center longitudinal joint	L&T cracking	Low-2	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	02	South longitudinal joint	L&T cracking	Low-2	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	03	North longitudinal joint	L&T cracking	Low-2	87 ft (26 m)
			L&T cracking	Low-3	13 ft (4 m)
			Weathering	Low	200 ft^2 (18 m^2)

Runway 9-27, Section 2 (Overlay)

Three random sample units were also inspected in section 2. While the majority of the longitudinal joints appeared to be tight, they were still visible. Photographs from Runway 9-27, section 2, are presented in Figure 42 through Figure 46. These joints are primarily rated as low-severity (Low-2) L&T cracking. Sample unit 3 of the longitudinal joint at the western end exhibited a visible crack less than 1/4 inch (0.6 cm) wide and was also rated as low-severity (Low-3) L&T cracking. Additionally, isolated transverse cracks of varying severities were observed in section 2, some of which carried through sample units 2 and 3. These transverse cracks ranged from low to medium severity. All sample units displayed low-severity weathering. Distress data are summarized in Table 9.



Source: APTech

Figure 42. Runway 9-27, Section 2, 2023 Overview (Looking East)



Source: APTech

Figure 43. Runway 9-27, Section 2, 2023 Paving Lane Joint (Low-2 Severity)



Source: APTech

Figure 44. Runway 9-27, Section 2, 2023, Paving Lane Joint (Low-3 Severity)



Source: APTech

Figure 45. Runway 9-27, Section 2, 2023, L&T Cracking (Medium Severity)



Source: APTech

Figure 46. Runway 9-27, Section 2, 2023, Weathering (Low Severity)

Table 9. Distress Data for Runway 9-27, Section 2

Section	Sample Unit	Location	Distress	Severity	Quantity
9/2	01	Center longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	02	South longitudinal joint	L&T cracking	Low-2	100 ft (30 m)
			L&T cracking (transverse direction)	Medium	2 ft (0.6 m)
			Weathering	Low	200 ft^2 (18 m^2)
	03	North longitudinal joint	L&T cracking	Low-2	100 ft (30 m)
			L&T cracking (transverse direction)	Low	4 ft (1.2 m)
			Weathering	Low	200 ft^2 (18 m^2)

Field Permeability Testing

As outlined in the project test plan, two falling head permeability tests were conducted in each sample unit. Tests were run for at least 10 min, after which time the material was assumed to be impermeable for the purpose of testing. The test results indicated that the water drainage rate during the initial stage (i.e., from 22 inches [56 cm] to 12.5 inches [32 cm]) was approximately 10 times faster over Low-3 severity L&T cracks compared to Low-2 severity L&T cracks. Tests conducted away from the joint (i.e., mat locations) showed the pavement was essentially impermeable. Field permeability results are summarized in Table 10.

Table 10. Summary of Field Permeability Testing

Section	Sample Unit	Location	Hydraulic Conductivity (10^{-5} cm/s)	Joint Rating
9/1	1	Joint	3,196	Low-2
		Mat	NP	--
	2	Joint	NP	Low-2
		Mat	NP	--
	3	Joint	44,088	Low-3
		Mat	NP	--
9/2	1	Joint	15,582	Low-3
		Mat	NP	--
	2	Joint	3,588	Low-2
		Mat	NP	--
	3	Joint	1,140	Low-2
		Mat	NP	--

Note: NP = non-permeable.

Summary—Runway 9-27 at Pekin Municipal Airport

Runway 9-27 at Pekin Municipal Airport was rehabilitated in 2019 using VRAM at the longitudinal paving lane locations. The east portion of the runway consisted of milling 9.5 inches (24 cm) and reconstructing the pavement, while the west end of the runway was milled and overlaid. Therefore, this case study site provides a comparison of VRAM placed on a new underlying asphalt base and placed on existing, milled asphalt but does not provide a comparison to the traditional cutback joint. This project also appears to be the first known application of VRAM on an airfield.

At the time of the survey, the pavement surface was 4 years old and was generally in excellent condition. The paving lane joints were still relatively tight but considered low-severity cracking in a PCI inspection. The overlaid section had joints of a greater length that were beginning to open (identified as Low-3). The overlaid section also had transverse cracks crossing the paving joints. Therefore, the VRAM paving joint performance is likely at least partially a representation of the condition of the underlying asphalt compared to the full-depth reconstruction section.

Field permeability testing suggested the joints are more permeable than the mat, which is expected. However, the joints that were beginning to open had much higher hydraulic conductivity, and it is believed that the readings may be indicative of the quality of the seal between the permeameter and pavement rather than the actual permeability of the material. Laboratory permeability testing may provide a more accurate assessment of the properties but is not included in this study.

Site Inspection—Decatur Airport, IL

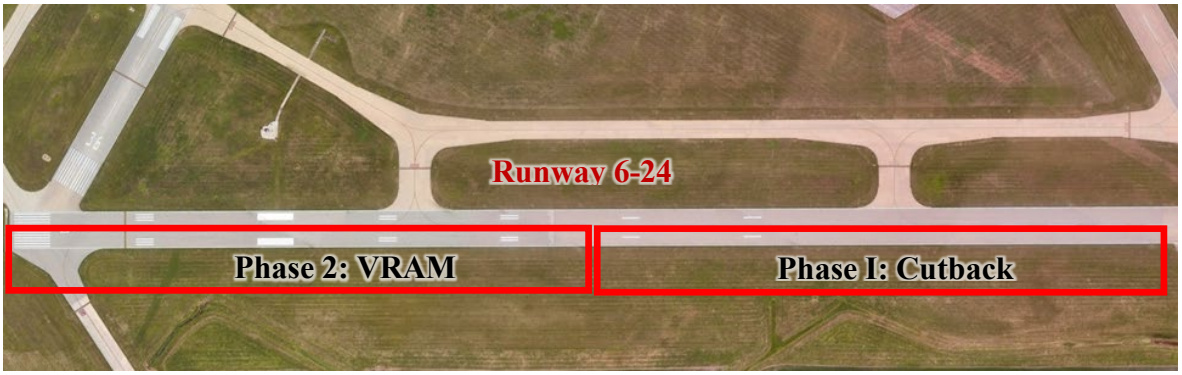
Project Description

Decatur Airport, located east of Decatur, IL, underwent a two-phase rehabilitation of Runway 6-24 during 2019 and 2020. The project consisted of milling the existing asphalt surface and placing a new asphalt overlay. Phase I of the project was completed in 2019, focusing on the rehabilitation of a portion of the runway located immediately southwest of the runway intersection, while phase II, completed in 2020, consisted of the portion from the southwest end of the phase I work to the Runway 6 approach. An overview of Runway 6-24 and the rehabilitation area is provided in Figure 47 and Figure 48.



Original Photo: © 2022 Google® (see Acknowledgments section). Image modified by APTech to identify field test locations.

Figure 47. Overview of Decatur Airport and Project Site

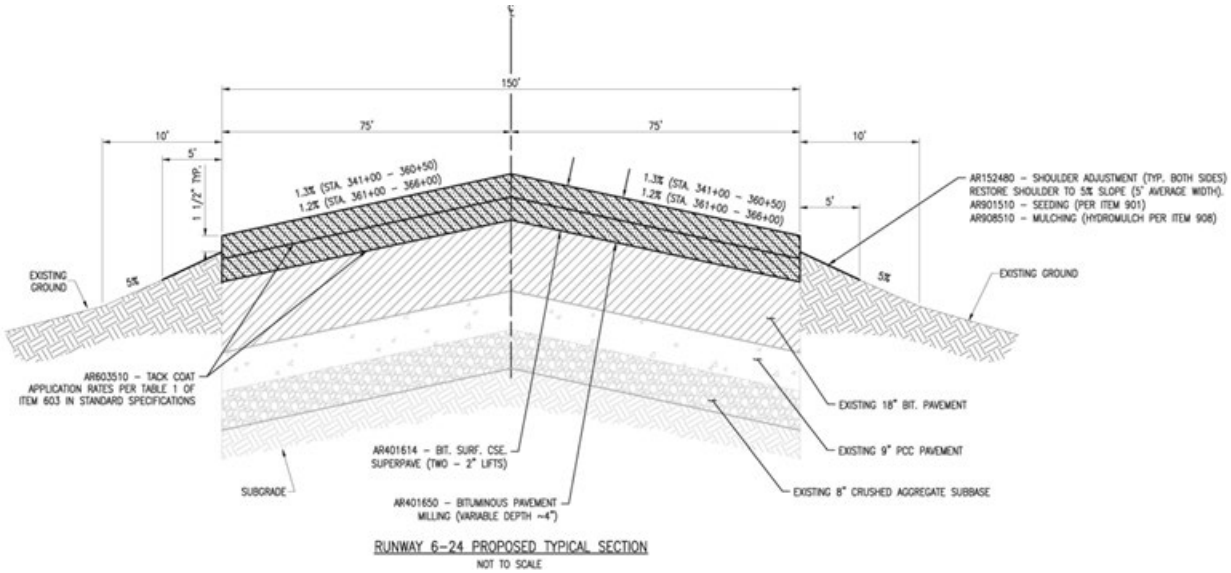


Original Photo: © 2023 Google® (see Acknowledgments section). Image modified by APTech to identify field test locations.

Figure 48. Runway 6-24 Project Area

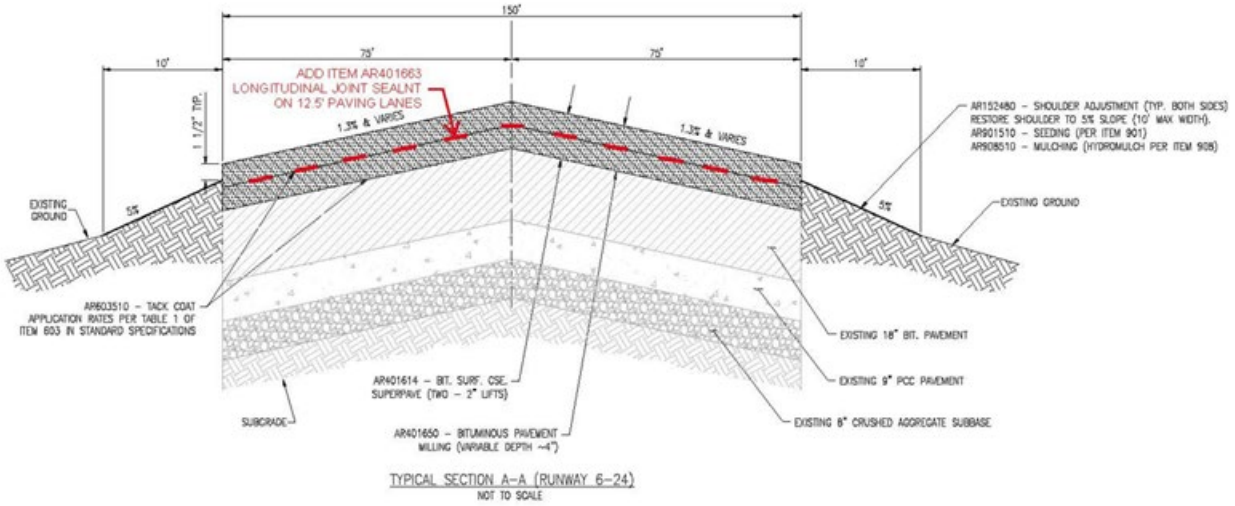
Airport Records

Typical cross-sections and repair details are provided in Figure 49 through Figure 51. The longitudinal joints in the phase I project did not receive VRAM (LJS) and were constructed with standard cutback joints. For the phase II portion, VRAM was applied at 11 longitudinal paving joints across the width of the runway. Additionally, at transverse cracks where partial- or full-depth repairs were completed, a reflection cracking control fabric treatment was used. The paving lane width was 12.5 ft (3.8 m). The runway surface was grooved.



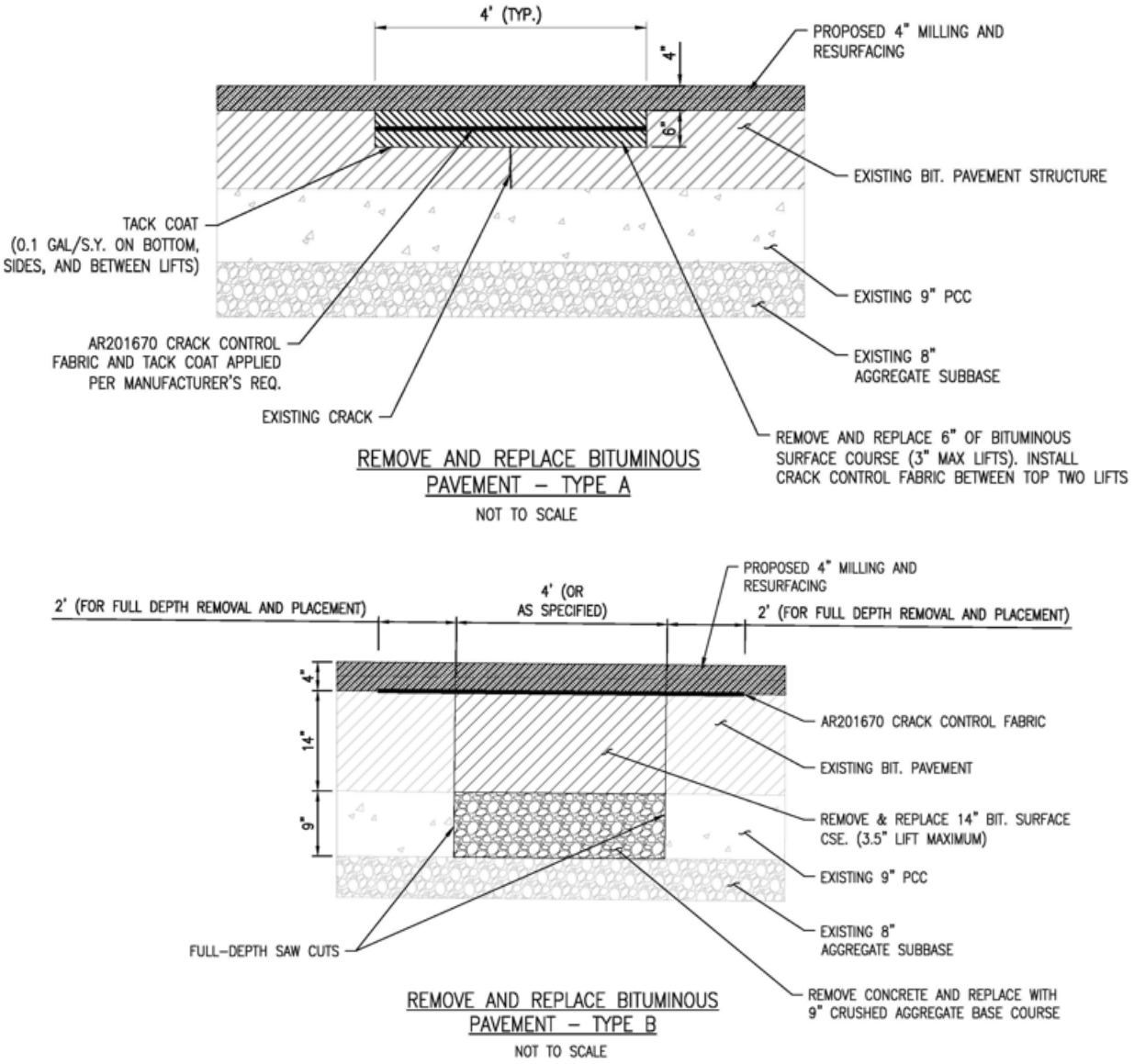
Source: Hanson Professional Services, Inc., 2018

Figure 49. Runway 6-24 Rehabilitation Typical Cross Section for Phase I [6]



Source: Hanson Professional Services, Inc., 2019

Figure 50. Runway 6-24 Rehabilitation Typical Cross Section for Phase II



Source: Hanson Professional Services, Inc., 2018

Figure 51. Partial- and Full-Depth Patching Details [6]

Construction specifications for the project included the following:

- Item AR401663 Longitudinal Joint Sealant.
- Item AR401614 Bituminous Surface Course—Superpave.

The VRAM material in phase 2 was applied in an 18-inch (45-cm)-wide strip at all longitudinal joint locations using a truck-mounted applicator (see Figure 52). The VRAM was applied at a rate of 1.51 lb/linear ft (2.25 kg/m) after the tack coat application.

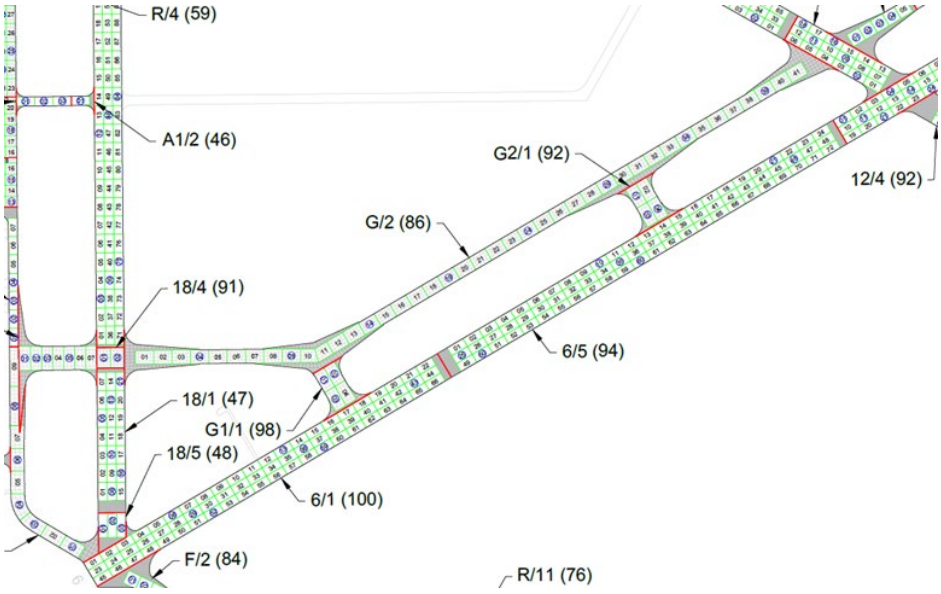


Source: Asphalt Materials, Inc.

Figure 52. Application of VRAM in Phase 2 of Runway 6-24 Rehabilitation

Decatur Airport is included in the Illinois APMS. As part of the APMS, APTech has conducted visual condition surveys at the airport over many years. The included pavement area corresponds to the following sections from the APMS (see Figure 53):

- Runway 6-24, Section 1 (construction phase 2).
- Runway 6-24, Section 5 (construction phase 1).



Source: APTech, 2021

Figure 53. Airport Pavement Management Plan Network Definition Map [5]

Conditions prior to the rehabilitation work (see Figure 54) show the paving lane joints primarily as low- to-medium severity L&T cracks, with many areas of the joints having been sealed. Note that sections 1 and 5 were combined as one section named “section 1” prior to the 2019 rehabilitation. The airport was also surveyed shortly after the rehabilitation of the runway, and paving joints were difficult to discern in many locations, as shown in Figure 54 through Figure 57.



Source: APTech

Figure 54. Decatur Airport, Runway 6-24, Section 1, 2019 Overview Before Rehabilitation (Looking Southwest)



Source: APTech

Figure 55. Decatur Airport, Runway 6-24, Section 1, 2021 Overview After Rehabilitation (Looking Southwest)



Source: APTech

Figure 56. Decatur Airport, Runway 6-24, Section 5, 2019 Overview Before Rehabilitation (Looking Southwest)



Source: APTech

Figure 57. Decatur Airport, Runway 6-24, Section 5, 2021 Overview after Rehabilitation (Looking Northeast)

Site Inspection

Runway 6-24 was inspected as part of this project on June 12, 2023. The pavement surface was approximately 3 years old for the VRAM section and 4 years old for the cutback joint section. Three, 100-ft (30-m) joint sample units were inspected for the VRAM joints, and two, 100-ft (30-m) joint sample units were selected for the cutback joints.

Runway 6-24, Section 1 (VRAM)

The 2,240-ft (682-m) length at the Runway 6 end (section 1) was constructed using VRAM. The majority of the longitudinal joints in this section appeared to have visible cracks less than 1/4-inch (0.6-cm) wide. These joints were rated as low-severity (Low-3 in the modified rating) L&T cracking. Additionally, all sample units displayed low-severity weathering. Distress data are summarized in Table 11. Overview and distress pictures from Runway 6-24, section 1, are presented in Figure 58 through Figure 60.

Table 11. Distress Data at Runway 6-24, Section 1

Section	Sample Unit	Location	Distress	Severity	Quantity
6/1	01	Center longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	02	South longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	03	North longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)



Source: APTech

Figure 58. Decatur Airport, Runway 6-24, Section 1, Overview (Looking East)



Source: APTech

Figure 59. Decatur Airport, Runway 6-24, Section 1, L&T Cracking (Low-3 Severity)



Source: APTech

Figure 60. Decatur Airport, Runway 6-24, Section 1, Weathering and Raveling (Low Severity)

Runway 6-24, Section 5 (cutback)

The 2,600-ft (792-m) length adjacent to Runway 6-24, section-1, was designated as section 5. This section was rehabilitated the year prior to section 1, and standard cutback joints were used at that time. Most of the longitudinal joints in this section appeared to have visible cracks less than 1/4-inch (0.6-cm) wide. These joints were rated as low-severity (Low-3) L&T cracking. Additionally, both sample units displayed low-severity weathering. Distress data are summarized in Table 12. Overview and distress pictures from Runway 6-24, section 5, are presented in Figure 61 to Figure 63.

Table 12. Distress Data at Runway 6-24, Section 5

Section	Sample Unit	Location	Distress	Severity	Quantity
6/5	01	Center longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	02	South longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)



Source: APTech

Figure 61. Decatur Airport, Runway 6-24, Section 5, Overview (Looking East)



Source: APTech

Figure 62. Decatur Airport, Runway 6-24, Section 5, L&T Cracking (Low-3 Severity)



Source: APTech

Figure 63. Decatur Airport, Runway 6-24, Section 5, Weathering (Low Severity)

Coring and Density Testing

No coring or density testing were performed.

Field Permeability Testing

Permeability testing was not conducted on Runway 6-24 pavement because of the transverse grooving along its entire length.

Summary of Peking Municipal Airport Inspection

The southwest end of Runway 6-24 at Decatur Airport was rehabilitated in two phases from 2019 to 2020, with the phase II 2020 mill and overlay using VRAM at the longitudinal paving lane locations. The 2019 construction consisted of standard cutback joints. The rehabilitation consisted of nominally milling 4 inches (10 cm) of existing asphalt and placing a new asphalt overlay. The VRAM was placed between lifts of new asphalt.

At the time of the survey, the pavement surface was 3 years old for the VRAM section and 4 years old for the cutback joint section. Both pavement sections were generally in very good condition. The paving lane joints were beginning to open in both sections but were less than 1/4-inch (0.6-cm) wide and considered low-severity cracking in a PCI inspection. Overall, the performance of the joints at the time of the inspection was similar.

Site Inspection—Coles County Memorial Airport, IL

Project Description

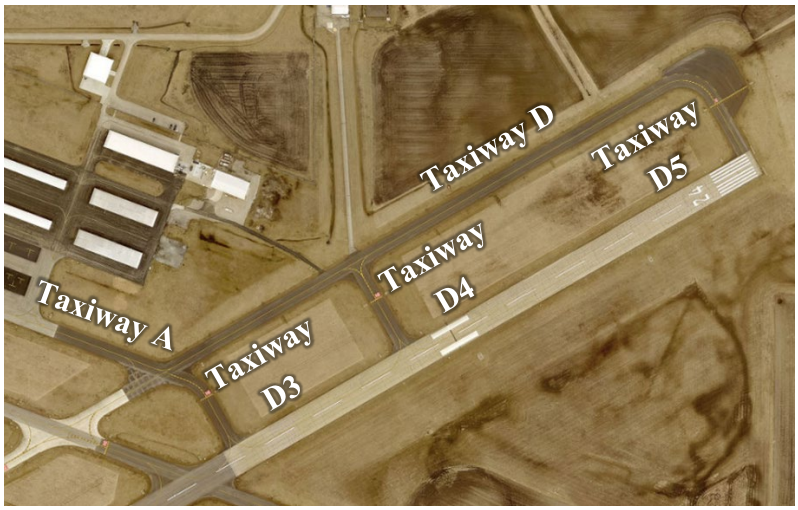
Taxiway D at Coles County Memorial Airport, located in Mattoon, IL, was rehabilitated in 2021. The project consisted of milling the existing asphalt surface and placing a new asphalt overlay. The project pavement consisted of an existing asphalt pavement over an aggregate base, except for the portion of Taxiway D west of Taxiway A, which was asphalt over concrete.

An overview of the Taxiway D rehabilitation area is provided in Figure 64 and Figure 65.



Source: Coles County GIS Portal

Figure 64. Overview of Coles County Airport and Taxiway Project Site



Source: Coles County GIS Portal

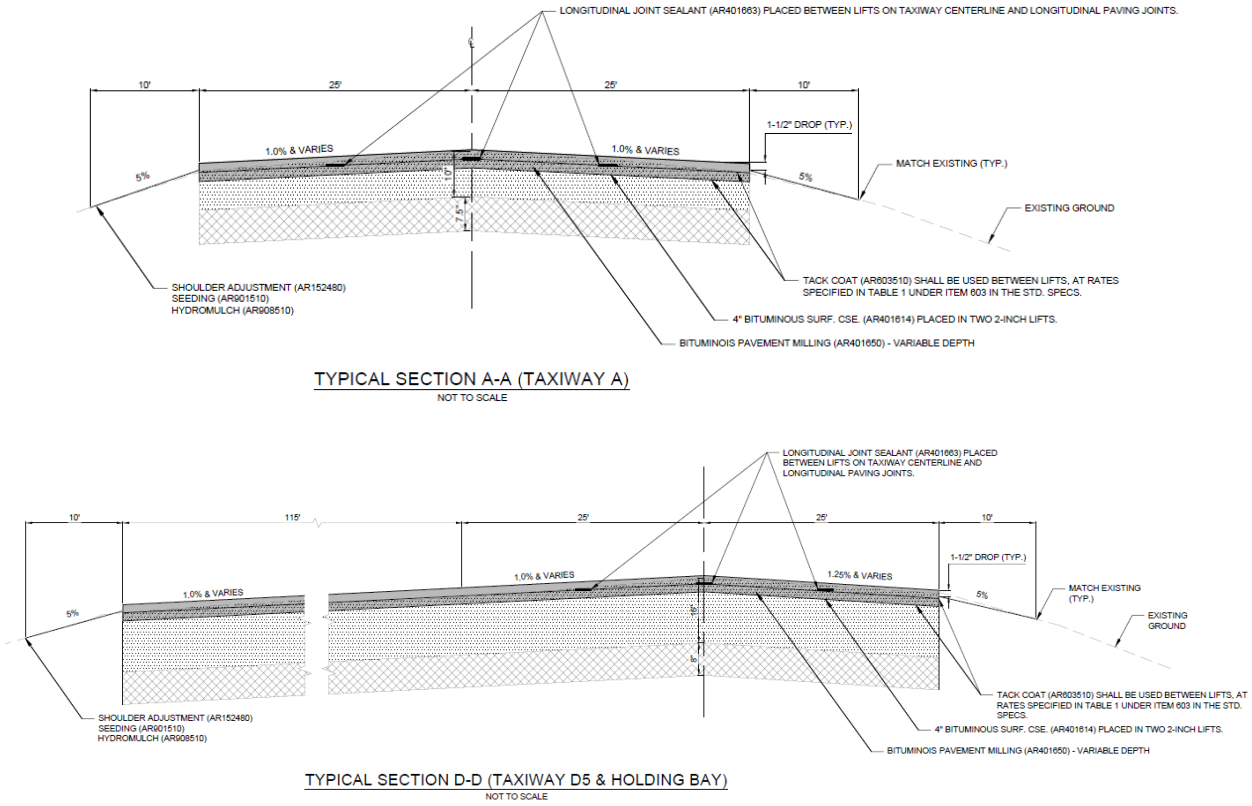
Figure 65. Overview of Coles County Airport, 2021 Taxiway D Rehabilitation Project Area, Including the D3, D4, and D5 Connecting Taxiways

Airport Records

The VRAM (LJS) was applied to the centerline joint and longitudinal paving joints left and right of center for the mainline taxiway. Subsequent longitudinal joints at the hold pad did not have VRAM and were constructed with standard cutback joints. At transverse cracks where partial- or full-depth repairs were completed, a reflection crack fabric treatment was also used. Typical cross sections and repair details are provided in Figure 66 and Figure 67.

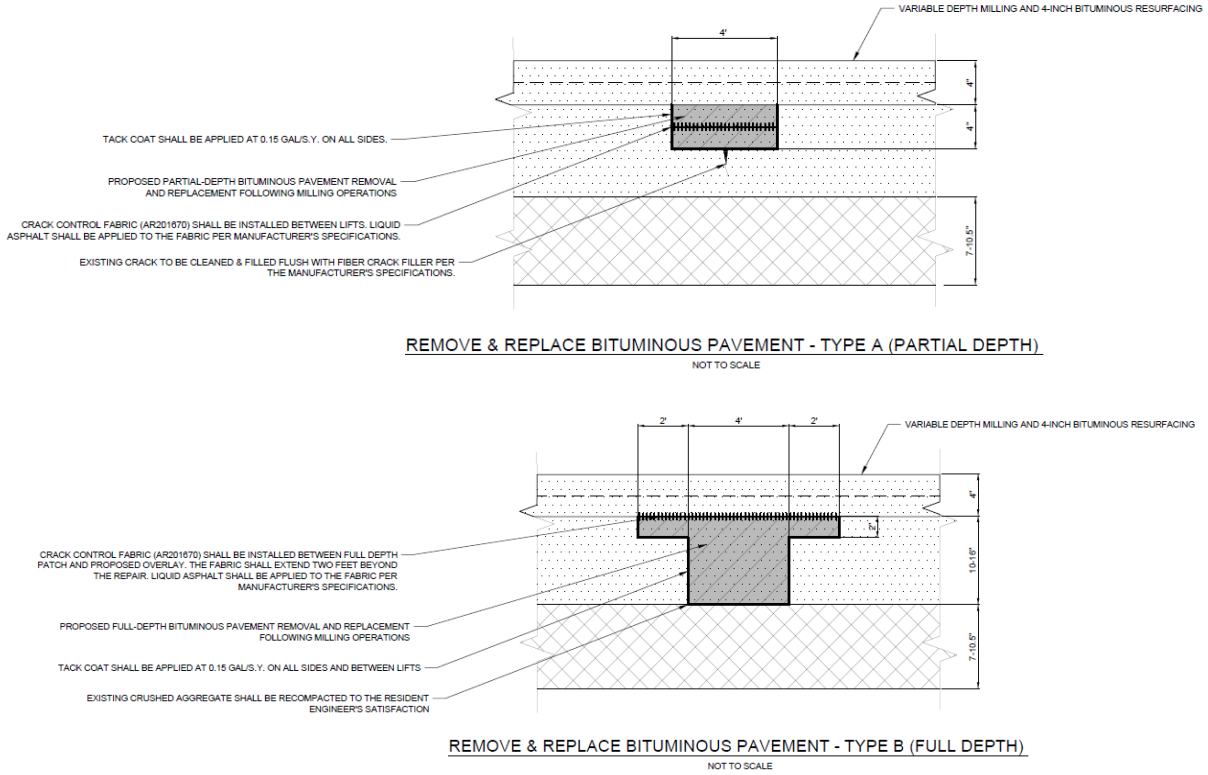
Construction specifications for the project included the following:

- Item 401660 Longitudinal Joint Sealant.
- Item 401650 Bituminous Surface Course—Superpave.



Source: Hanson Professional Services, Inc.

Figure 66. Taxiway D Rehabilitation Typical Cross Sections [7]



Source: Hanson Professional Services, Inc.

Figure 67. Partial- and Full-Depth Patching Details [7]

The VRAM material was applied in an 18-inch (45-cm)-wide strip at the longitudinal joint locations using a truck-mounted applicator (see Figure 68). The VRAM was applied at a rate of 1.51 lb/linear ft (2.25 kg/m) after tack coat application.



Source: Asphalt Materials, Inc.

Figure 68. VRAM Application on Taxiway D After Tack Coat

Pavement Condition Records

Coles County Airport is included in the Illinois APMS. The APMS plan network definition map is presented in Figure 69. As part of the APMS, APTech has conducted visual condition surveys at the airport over many years. The pavement area corresponds to Taxiway D, Sections 1, 2 (including hold pad and Taxiway D5), and 3 from the Illinois APMS.



Source: APTech, 2021

Figure 69. Airport Pavement Management Plan Network Definition Map [5]

Conditions prior to the rehabilitation work (shown in Figure 70 and Figure 71) show the paving lane joints primarily as low- to medium-severity L&T cracks, with many areas of the joints having been sealed (although joint sealant was failing). The airport was also surveyed shortly after rehabilitation of the runway, and paving joints were very tight, as shown in Figure 72 and Figure 73.



Source: APTech

Figure 70. Coles County Airport, Taxiway D, Section 1, 2019 Overview Before Rehabilitation Looking Southwest)



Source: APTech

Figure 71. Coles County Airport, Taxiway D, Section 2, 2019 Overview Before Rehabilitation (Looking Southwest; Note Holding Pad is included in Taxiway Pavement Management Section)



Source: APTech

Figure 72. Coles County Airport, Taxiway D, Section 1, 2021 Overview After Rehabilitation (Looking Northeast)



Source: APTech

Figure 73. Coles County Airport, Taxiway D, Section 2, 2021 Overview After Rehabilitation (Looking Northeast)

Site Inspection

Taxiway D was inspected as part of this project on June 7, 2023. The pavement surface was 2 years old at the time of the survey. Three, 100-ft (30-m) joint sample units were inspected on the Taxiway D, section 2 mainline, and two, 100-ft (30-m) joint sample units were selected on the Taxiway D, section 2 hold pad.

Taxiway D, Section 2 Mainline

The centerline longitudinal joint was covered with yellow paint marking for the full length of the section, so no sample units were selected at that location. However, a full-length visual inspection revealed no apparent cracking at the centerline longitudinal joint. Three random sample units from this section were inspected for rating purposes, one on the north longitudinal joint and two on the south longitudinal joint. All the longitudinal joints appeared to have a visible crack less than 1/4-inch (0.6-cm) wide and were rated as low-severity (Low-3 in modified ratings) L&T cracking. Additionally, all sample units displayed low-severity weathering. Summarized distress data are presented in Table 13. Overview and distress pictures from Taxiway D, section 2 mainline are presented in Figure 74 to Figure 77.

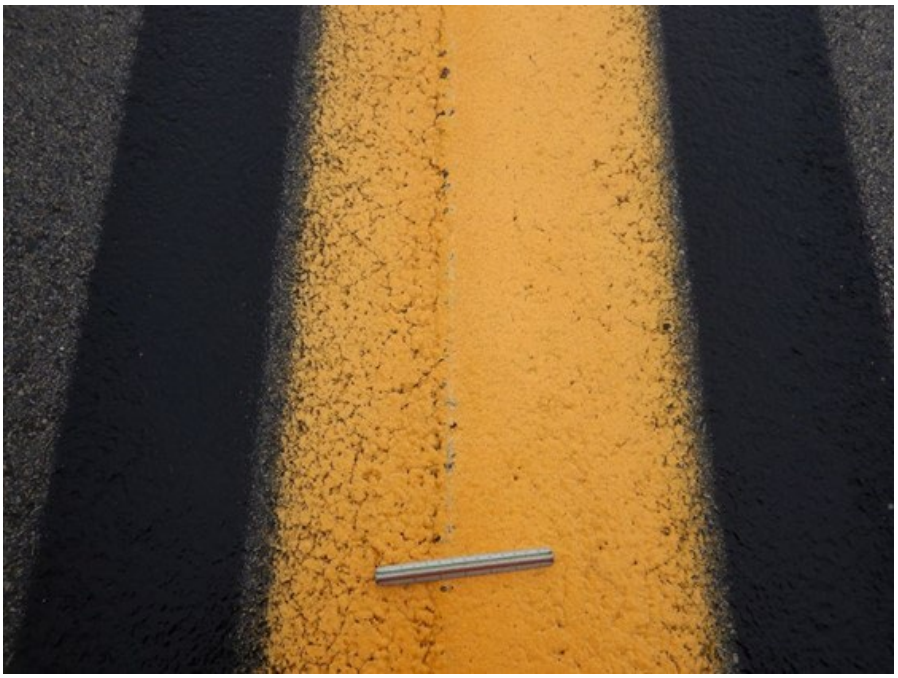
Table 13. Distress Data at Taxiway D, Section 1 Mainline

Section	Sample Unit	Location	Distress	Severity	Quantity
D/2 Mainline	01	North longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	02	South longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	03	South longitudinal joint	L&T cracking	Low-3	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)



Source: APTech

Figure 74. Coles County Airport, Taxiway D, Section 2, 2023 Mainline Overview (Looking East)



Source: APTech

Figure 75. Coles County Airport, Taxiway D, Section 2, Mainline, Centerline Longitudinal Joint



Source: APTech

Figure 76. Coles County Airport, Taxiway D, Section 2, Mainline, L&T Cracking (Low-3 Severity)



Source: APTech

Figure 77. Coles County Airport, Taxiway D, Section 2, Mainline, Weathering (Low Severity)

Taxiway D, Section 2 Hold Pad

The Taxiway D, section 2 hold pad did not have VRAM at the construction joints and, therefore, represents a control section. In this section, two 100-ft (30-m) sample units were inspected for rating purposes. The longitudinal joint in sample 1 was visibly recognizable and was rated as low-severity (Low-2) L&T cracking. The condition of the longitudinal joint in sample 2 varied. Most of the joint was not easily visible and was rated as low-severity (Low-1) L&T cracking. The remainder of the paving joint was rated as low-severity (Low-2) L&T cracking. Additionally, all sample units displayed low-severity weathering. Distress data are presented in Table 14. Overview and distress pictures from the Taxiway D, section 2 hold pad are presented in Figure 78 through Figure 81.

Table 14. Distress Data at Taxiway D, Section 2 Hold Pad

Section	Sample Unit	Location	Distress	Severity	Quantity
D/2 Hold Pad	01	West longitudinal joint	L&T cracking	Low-2	100 ft (30 m)
			Weathering	Low	200 ft^2 (18 m^2)
	02	East longitudinal joint	L&T cracking	Low-1	68 ft (20 m)
			L&T cracking	Low-2	32 ft (9 m)
			Weathering	Low	200 ft^2 (18 m^2)



Source: APTech

Figure 78. Coles County Airport, Taxiway D, Section 2, Hold Pad, Overview (Looking North)



Source: APTech

Figure 79. Coles County Airport, Taxiway D, Section 2, Hold Pad, L&T Cracking (Low-1 Severity)



Source: APTech

Figure 80. Coles County Airport, Taxiway D, Section 2, Hold Pad, L&T Cracking (Low-2 Severity)



Source: APTech

Figure 81. Coles County Airport, Taxiway D, Section 2, Hold Pad, Weathering (Low Severity)

Coring and Density Testing

No coring or density testing were performed.

Field Permeability Testing

Two falling head permeability tests were conducted at each sample unit as outlined in the project test plan. The maximum duration for all tests was limited to 600 sec (i.e., 10 min). The test results indicated that the average water drainage rate during the initial stage (i.e., from 22 inches [56 cm] to 12.5 inches [32 cm]) was approximately four times faster over Low-3 severity L&T cracks in the section 2 mainline compared to Low-2 severity L&T cracks in the section 2 hold pad. However, permeability was significantly reduced in the mat at a 48-inch (1.2-m) offset from the joint. There was a slight dip in the pavement along some of the paving joints, which may have impacted the seal on the permeameter. Additionally, at Low-1 severity L&T cracks and 48-inch (1.2-m) offset locations, tests took more than 600 sec to complete the initial drainage process from 22 inches (56 cm) to 12.5 inches (32 cm). Water drainage also took more than 600 sec to complete the full drainage process from 22 inches (56 cm) to 3 inches (8 cm) at Low-2 severity L&T cracks. Permeability test summary data are presented in Table 15.

Table 15. Permeability Test Summary

Section	Sample Unit	Offset from the Joint	Time, sec		Remarks
			12.5 inches (32 cm)	3 inches (8 cm)	
D/2 Mainline	1	At the joint	42	124	Over Low-3 L&T crack.
D/2 Mainline	1	48 inches (1.2 m) from the joint	>600	>600	
D/2 Mainline	2	At the joint	70	227	Over Low-3 L&T crack.
D/2 Mainline	2	48 inches (1.2 m) from the joint	>600	>600	
D/2 Mainline	3	At the joint	98	312	Over Low-3 L&T crack.
D/2 Mainline	3	48 inches (1.2 m) from the joint	>600	>600	
D/2 Hold Pad	1	At the joint	285	>600	Over Low-2 L&T crack.
D/2 Hold Pad	1	48 inches (1.2 m) from the joint	>600	>600	
D/2 Hold Pad	2	At the joint	>600	>600	Over Low-1 L&T crack.
D/2 Hold Pad	2	48 inches (1.2 m) from the joint	>600	>600	

Summary of Coles County Memorial Airport Inspection

Taxiway D at Coles County Airport was rehabilitated in 2021 using VRAM at the longitudinal paving lane locations along the mainline taxiway. The rehabilitation consisted of nominally milling 4 inches (10 cm) of existing asphalt and placing a new asphalt overlay. The VRAM was placed between lifts of new asphalt. The hold pad area incorporated traditional cutback joints and served as a control section for comparison purposes.

At the time of the survey, the pavement surface was 2 years old and was generally in excellent condition. The mainline paving lane joints were still relatively tight but would be considered low-severity cracking in a PCI inspection. The hold pad had some sections of joints that were not opening at all. At only 2 years of age, there was little discernible difference between the VRAM-treated and traditional cutback joints at this site. The control section paving joint was even less noticeable than the treated section.

Field permeability testing confirmed that joints were more permeable than the mat. The barely visible joints had permeabilities similar to the mat locations. However, higher permeability readings may indicate a lower-quality seal between the permeameter and pavement rather than the actual permeability of the material.

Summary of Existing Project Inspections

This section summarizes information on the existing VRAM projects and the results of the field inspections for each.

US-51 in Decatur, IL

- Longitudinal joint test sections constructed in 2002 included two VRAM test sections and two control sections with butt joints. The two VRAM sections consisted of applications of VRAM with 12- and 18-inch (30- and 45-cm) widths. Each section was approximately 100 ft (30 m).
- The test sections were inspected on Oct. 3, 2022. After 20 years, the joints treated with VRAM visually performed better than the control butt joint, with VRAM joints having higher PCIs compared to the butt joint control sections. The VRAM sections had much less cracking along the longitudinal joint and less patching than the control sections.
- Density testing was inconclusive due to the significant extent of cracking along the joint.
- Although deterioration was observed in all the cores extracted from the test sections, cores retrieved from joints with VRAM treatment were mostly intact, in contrast to pieces of cores obtained from control butt joints.
- Of the six existing projects evaluated, the US-51 project was the only one that showed evidence that the joint with VRAM performed better than the butt joint in the control section, however, some of the other sections used cutback joints in the control section.

Iowa Highway 13 in Marion, IA

- A section of the highway was resurfaced in July 2016 and included a control section and two VRAM test sections applied to the longitudinal joint using a butt joint. VRAM segment number 1 was applied at an application rate of 1.47 lb/linear ft (2.19 kg/m) and 18 inches (45 cm) wide, while segment number 2 was applied at an application rate of 1.80 lb/linear ft (2.68 kg/m) and 18 inches (45 cm) wide. The test sections were inspected in November 2022 and April 2023.
- Since a 2016 resurfacing project, all longitudinal joints had been routed and sealed as part of a routine highway maintenance program, making it difficult to identify possible differences in the performance of the longitudinal joints for the VRAM section and the control section.
- The density measurements showed a trend consistent with the hypothesis that the VRAM is reducing the voids in the centerline joint. However, the 1.80 lb/linear ft

(2.68 kg/m) application rate had a lower relative density increase compared to the 1.47 lb/linear ft (2.19 kg/m) application rate.
- Obtaining reliable field permeability measurements was not possible because deterioration along the longitudinal joint prevented a complete seal with the pavement, allowing water to flow laterally along the joint.
- Assessment of VRAM joint performance was inconclusive.

Iowa Highway 57 West of Ackley, IA

- A section of Iowa Highway 57 was resurfaced in 2016 with VRAM applied to the longitudinal joint using a butt joint. VRAM was applied at an application rate of 1.44 lb/linear ft (2.14 kg/m). An onsite inspection took place in May 2023.
- Maintenance and safety activities since construction included crack sealing of the longitudinal joint and adding a centerline rumble strip. Therefore, it was not possible to evaluate differences in the longitudinal joints for the VRAM section and the control section.
- The NoNuke gauge density measurements showed a trend that contradicts the hypothesis that VRAM increases the density at the longitudinal joint. This could be due to the centerline rumble strip grinding depositing material that interfered with the NoNuke gauge, or it could be due to the centerline joint sealant density reducing the density of the core.
- Obtaining reliable permeability measurements was not possible due to deterioration along the longitudinal joint that prevented a seal between the permeameter and the pavement, allowing water to flow laterally along the surface.
- Assessment of the VRAM joint performance was inconclusive.

Pekin Municipal Airport, IL

- Runway 9-27 at Pekin Municipal Airport was rehabilitated in 2019 using VRAM at the longitudinal paving lane locations. The east portion of the runway consisted of milling and reconstructing the pavement, while the west end of the runway was milled and overlaid. Therefore, this case study site provided a comparison of VRAM placed on a new, underlying asphalt base and placed on existing, milled asphalt, but it did not provide for a comparison to the traditional cutback joint. This project is the first known application of VRAM on an airfield.
- Runway 9-27 was inspected as part of this project on June 5, 2023. During the inspection, the pavement surface was 4 years old and was generally in excellent condition. The paving lane joints were still relatively tight but would be considered low-severity cracking. The overlaid section had joints of a greater length that were beginning to open. The overlaid section also had transverse cracks across the

paving joints. Therefore, the VRAM paving joint performance was likely a partial representation of the condition of the underlying asphalt compared to the full-depth reconstruction section.

- Field permeability testing indicated that the joints were more permeable than the mat, which was expected. However, the joints that were beginning to open had much higher hydraulic conductivity, and it is believed that the readings may be indicative of the quality of seal between the permeameter and pavement rather than the actual permeability of the material.
- It was not possible to coordinate coring and density testing with the airport.
- Assessment of VRAM joint performance was inconclusive.

Decatur Airport, IL

- Decatur Airport Runway 6-24 was rehabilitated in two phases from 2019 to 2020, with the phase II 2020 mill and overlay using VRAM at the longitudinal paving lane joints. VRAM was applied in an 18-inch (45-cm)-wide strip. The phase I 2019 construction consisted of standard cutback joints.
- The runway was inspected on June 12, 2023. At the time of the visit, the pavement surface was approximately 3 years old for the VRAM section and 4 years old for the cutback joint section. Three, 100-ft (30-m) joint sample units were inspected for the VRAM joints, and two, 100-ft (30-m) joint sample units were selected for the cutback joints. Both types of pavement sections were generally in very good condition. The paving lane joints began opening in both sections but were less than 1/4-inch (0.6-cm) wide and considered low-severity cracking. Overall, the performance of the joints at the time of the inspection was similar.
- Permeability testing was not conducted on Runway 6-24 pavement because of the transverse grooving along its entire length.
- No coring or density testing were performed.
- Assessment of VRAM joint performance was inconclusive.

Coles County Memorial Airport, IL

- Taxiway D at Coles County Airport was rehabilitated in 2021 using VRAM at the longitudinal paving lane joints. The rehabilitation consisted of milling 4 inches (10 cm) of existing asphalt and placing a new asphalt overlay. The VRAM was placed between lifts of new asphalt. The hold pad area utilized traditional cutback joints and served as a control section for comparison purposes. The VRAM material was applied in an 18-inch (45-cm)-wide strip at a rate of 1.51 lb/linear ft (2.25 kg/m) after tack coat application.

- Taxiway D was inspected on June 7, 2023. At the time of the survey, the pavement surface was 2 years old and was generally in excellent condition. The mainline paving lane joints were still relatively tight but would be considered low-severity cracking. The hold pad had some sections of joints that were not opening at all. At only 2 years of age, there was little difference between the VRAM-treated and traditional cutback joints.
- Field permeability testing confirmed that joints were more permeable than the mat. The barely visible joints had permeabilities that were more similar to the mat locations. However, higher permeability readings may be indicative of a lower-quality seal between the permeameter and pavement rather than the actual permeability of the material.
- No coring or density testing was performed.
- Assessment of VRAM joint performance was inconclusive.

Site Visits for New VRAM and RPE Projects

Site Visit Locations

As part of this research study, three new field sites were visited to document the application of VRAM and RPEs. These sites consisted of three airport pavements. Table 16 summarizes the project locations, the inspection date, and the type of treatment applied.

Table 16. New VRAM and RPE Projects

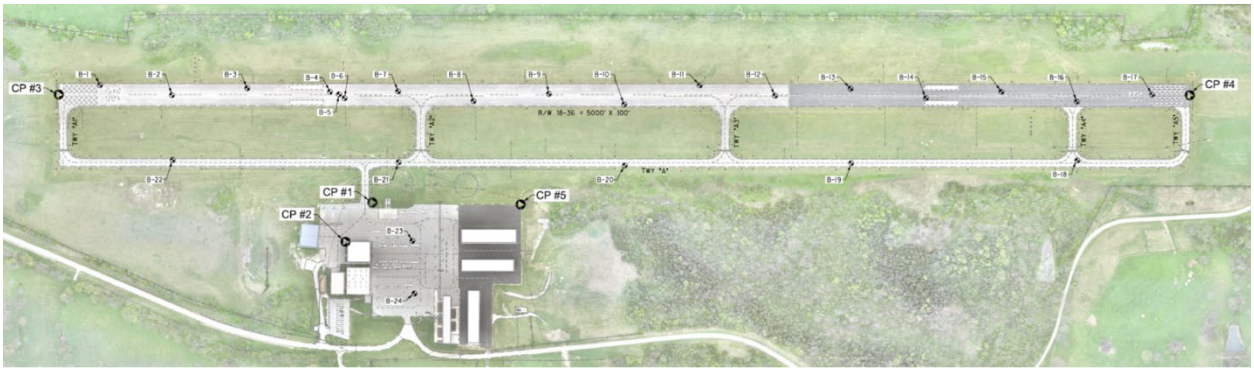
Proj. #	Location	Type of Treatment	Inspection Date
1	Central Kentucky Regional Airport, Richmond, KY	VRAM	July 28, 2023
2	Huntsville Executive Airport, Meridianville, AL	VRAM and RPE	Nov. 17, 2023
3	Moton Field Municipal Airport, Tuskegee, AL	VRAM and RPE	April 2024

The following sections summarize each of the three new project inspections.

Central Kentucky Regional Airport, Richmond, KY

Project Description

The Central Kentucky Regional Airport is located in Richmond, KY, just off Interstate 75. Runway 18-36 is 5,000 ft (1,524 m) long by 100 ft (30 m) wide and has an existing pavement structure consisting of an asphalt layer over an aggregate base on top of the subgrade. Coring was performed along the runway as shown in Figure 82, and the results showed that the average thicknesses were 7 inches (17 cm) for the asphalt layer and 9.5 (24 cm) inches for the aggregate base.



Source: STV, Inc.

Figure 82. Coring Locations Along Runway 18-36

The runway rehabilitation consisted of a double-layer crack relief seal coat (CRSC) followed by a 2-inch-thick asphalt overlay. The CRSC is an application of polymerized emulsion and a cover aggregate that is rolled and broomed. The process is repeated to form a second coverage. Before the CRSC, joint and crack repairs were performed on the existing pavement.

The asphalt mixture in the overlay was gradation 2, as per Kentucky Transportation Cabinet specifications, with a nominal maximum aggregate size of 19.0 mm. The project specifications required a PG 64S-22 binder, according to AASHTO M332. In addition, based on the existing pavement conditions, the following modifications were required to help ensure the desired pavement lifespan performance:

- Addition of aramid fibers at a minimum dosage rate of 2.1 ounces per ton.
- Addition of crumb rubber modifier at a minimum dosage rate of 10 percent by weight of total asphalt binder, 98 percent of particles passing a number 30 sieve.
- Addition of liquid anti-stripping additive at a dosage rate of 0.5 percent by weight of binder.

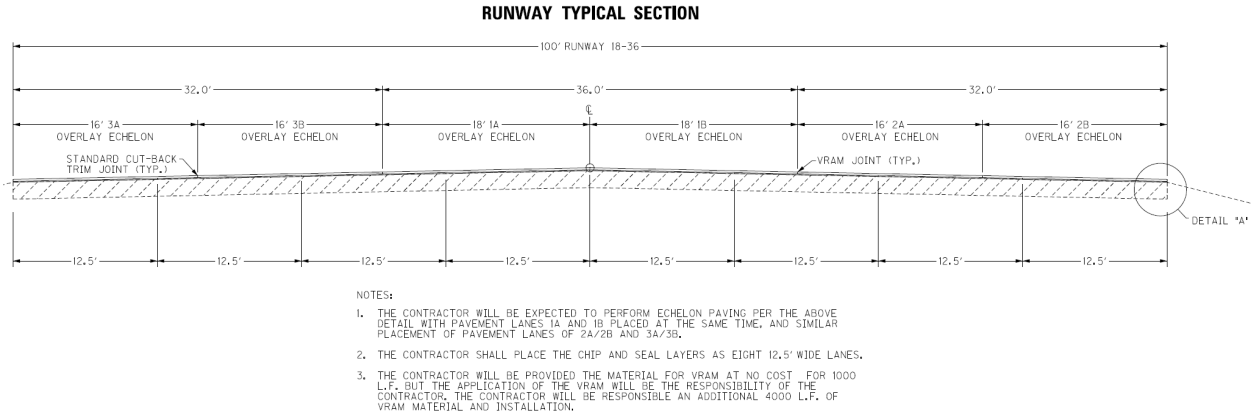
The mix design criteria are shown in Table 17.

Table 17. Mix Design Criteria

Test Property	Value	Test Method
Number of Gyrations	65	AASHTO T312
Air Voids, %	3.0–3.5	AASHTO T312
Voids in Mineral Aggregate, %	≥15.0 for gradation 2	AASHTO R35
Tensile Strength Ratio	≥80 at a saturation level of 70–80%	ASTM D4867
Hamburg Wheel Tracking Test	Less than 12.5 mm rut depth for PG 64S-22 at 7,500 passes	AASHTO T324 at 50 °C Test Temperature
KYCT Index Value	≥100	KM 64-450 at 25 °C

Note:
KM = Kentucky Method
KYCT = Kentucky Cracking Test

Figure 83 shows the typical runway section. Echelon paving was performed to minimize the number of cold joints. Cold joints were treated with one of two methods: cutback joint per FAA Specification P-401, Section 4.14, or application of VRAM.

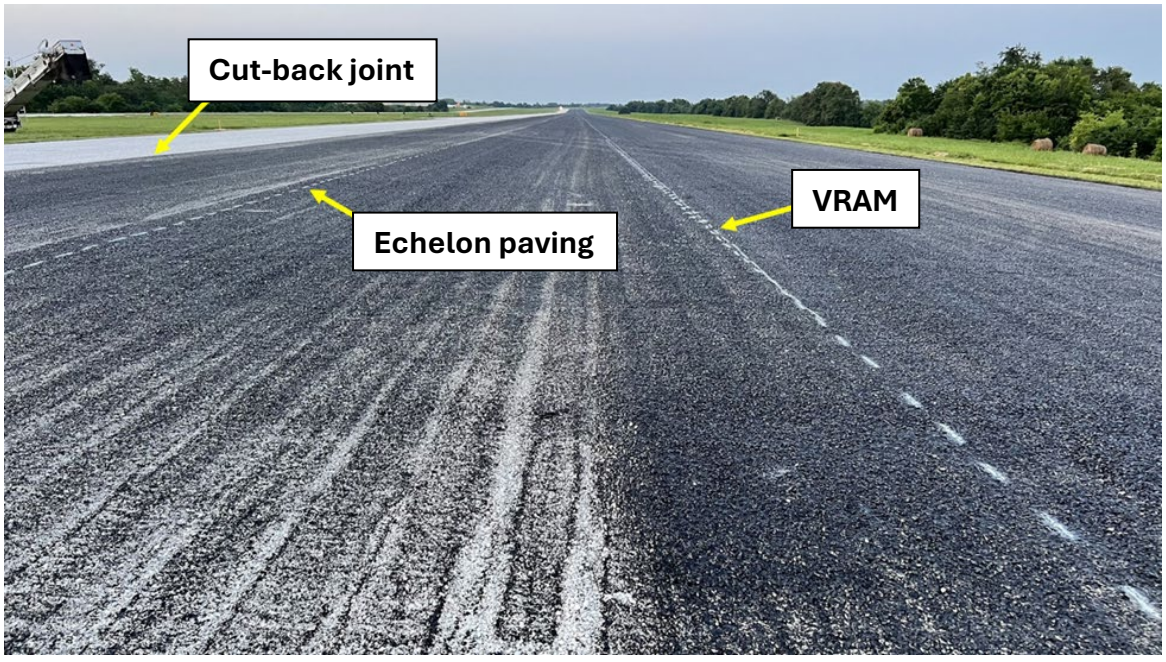


Source: STV, Inc

Figure 83. Runway Section

Construction

Construction activities were performed in the summer of 2023. Placement of the overlay started on July 28 for the first half of the runway width. Three lanes were set up as shown in Figure 84. As shown in the runway section in Figure 83, the VRAM joint was 32 ft (9 m) from the edge of the pavement, while the cutback joint was placed in the center of the runway (50 ft [15 m] from the edge of the pavement). Echelon paving was performed between the VRAM and cutback joints. An SS-1H tack coat had been applied previously to the CRSC surface at a rate of 0.04–0.05 gal/yd^2 (0.18–0.23 L/m^2).



Source: NCAT

Figure 84. Paving Lane Setup

VRAM application started shortly after 7 a.m. The process began by checking the application rate of the product. The supplier indicated that this was the first project where VRAM was applied to a seal coated surface; however, no modifications to the target application rate were made to account for the rougher texture. The rate was checked by performing a short pass of the distributor truck (approximately 50 ft [15 m]) over a pre-weighted roofing felt pad and obtaining the weight of the material per linear ft, as shown in Figure 85. The target application rate was 0.95 lb/linear ft (1.41 kg/m), and the actual rate was 0.98 lb/linear ft (1.46 kg/m). The application width was 18 inches (45 cm).

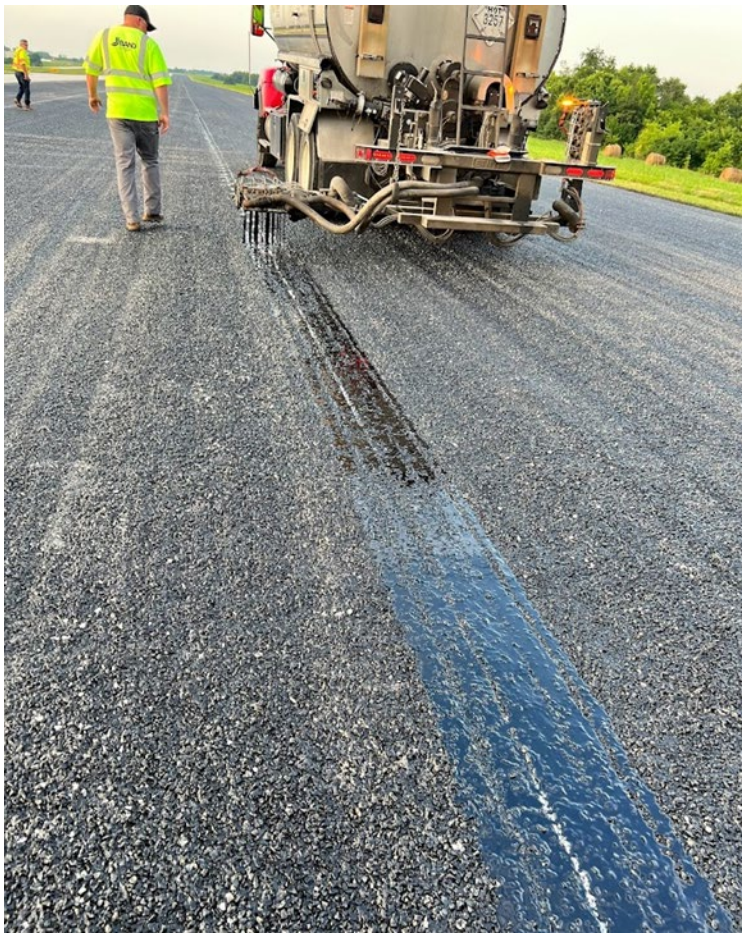


Source: NCAT

Figure 85. Application Rate Check

During the trial pass, it was observed that the application was not uniform (see Figure 86). The operator proceeded to clean the nozzles in the distributor truck to ensure uniform coverage (see Figure 87). Once it was verified that the desired application rate and

uniformity were obtained, the operator proceeded with VRAM application for the entire runway length at a temperature of 320 °F (160 °C). The air temperature was approximately 73 °F (22 °C) at the time of application (7:30 a.m.), and the material cooled down enough to be walked on without any tracking after 10 min. No construction traffic crossed the VRAM at any point.



Source: NCAT

Figure 86. Trial Application with Non-Uniform Coverage



Source: NCAT

Figure 87. Nozzle Cleanup

Echelon paving started approximately 1 hr later, with the first paver placing the overlay over the VRAM (see Figure 88) and mat compaction following soon after. The second paver started 35 min behind the first paver. Although the two pavers were spread out, the mat temperature in the first lane was 220 °F (104 °C) at the time placement of the second lane began. Figure 89 shows a wide view of the operation.



Source: NCAT

Figure 88. Placement of Overlay over VRAM



Source: NCAT

Figure 89. Echelon Paving of Runway

The remaining cold joint was cut back as per FAA specifications, as shown in Figure 90. The operation began around noon, a little over 3 hr after the initial placement of the overlay.



Source: Asphalt Materials, inc.

Figure 90. Cold Joint Trimming

Summary

The Central Kentucky Regional Airport project provided an opportunity to compare three construction techniques used to address joint deterioration in airport pavements: echelon paving, cutback joints, and VRAM. During the field visit, it was observed that paving was completed without issues. The VRAM application process was fast and did not result in any complications.

Huntsville Executive Airport, Meridianville, AL

Project Description

As part of the reconstruction of the taxiway on the Huntsville Executive Airport in Meridianville, AL, experimental sections were installed for the evaluation of three alternative methods of longitudinal joint construction: VRAM without cutting back the unconfined side of the longitudinal joint, RPE without cutting back the longitudinal joint, and RPE on a traditional airfield cutback longitudinal joint. The location of the experimental sections is identified by the box drawn on Figure 91.

The asphalt contractor for the paving work was SJ&L General Contractors from Huntsville, AL. The VRAM was installed by Hall Brothers, and the RPE was installed by Asphalt Materials, Inc.



Source: © Google® Maps

Figure 91. Aerial Photo of the Huntsville Executive Airport with a Box Drawn Around the Test Location

Site Visit

During the installation visit on Nov. 14, 2023, the VRAM was installed on a previously milled, crack-sealed, and patched surface of the short crossover taxiway from the northernmost hangers to the main taxiway that parallels the runway. The extensive patching included a long patch under the longitudinal joint where the VRAM was to be

installed. This short section of the taxiway varied in width from 38 to 70 ft (12 to 21 m) and was approximately 465 ft (142 m) long.

VRAM Installation

The VRAM material was applied along the centerline longitudinal joint of the short crossover taxiway, which was paved four pulls wide. The contractor used a Cimline MA4™ kettle (see Figure 92) to heat and spray the VRAM, which was delivered as blocks.



Source: © 2022 Google®

Figure 92. VRAM Installation Equipment

The morning of the installation was cool for north Alabama, and the contractor had a significant delay waiting for the kettle to heat the material to the installation temperature. Just before 11 a.m., the contractor conducted a test shot of the material approximately 5 ft (1.5 m) from the intended longitudinal joint. The test appeared satisfactory, and the application proceeded at 11:05 a.m. At the time of installation, the air temperature was 55 ºF (13 ºC), the surface was 70 ºF (21 ºC), and the material was applied at 320 ºF (160 ºC). Within 3 min of application, the VRAM material had cooled to 135 ºF (57 ºC). The installation was 18.5 inches (47 cm) wide and approximately 465 ft (142 m) long from a concrete drain to the main taxiway. The application rate was 1.51 lb/linear ft (2.25 kg/m), as recommended by Asphalt Materials, Inc. Figure 93 illustrates the application process.



Source: NCAT

Figure 93. Installation of the VRAM Material

The paving operation was delayed to Nov. 15, 2023, the day after the VRAM was installed. A tack coat was applied to the entire milled surface of the taxiway at around 9 a.m. on the morning of November 15. The contractor was careful to keep the tack coat off the VRAM, resulting in only a slight overspray. Paving started at approximately 10:30 a.m. on the aprons adjacent to the main taxiway at the west end of the crossover. The contractor was cautious to keep construction traffic off the VRAM. No pickup was observed of the VRAM by the paver tracks or haul trucks. Figure 94 shows the longitudinal joint treated with VRAM after the tack coat application.



Source: NCAT

Figure 94. Longitudinal Joint Treated with VRAM Material After Tack Coat Installation

Paving of the northernmost pull started at about 11 a.m. A second paver began on the adjacent pull at 11:20 a.m. to pave in echelon. The second paver covered the VRAM on the northern side of the application by 9 inches (23 cm) (see Figure 95). The ambient temperature at this time was 56 ºF (13 ºC), the surface of the VRAM was 74 ºF (23 ºC), and the mix in the hopper was 315–320 ºF (157–160 ºC).



Source: NCAT

Figure 95. Asphalt Mixture Application Across the VRAM-Treated Joint

The VRAM material representative instructed the contractor to overhang the unconfined edge by 6–12 inches (15–30 cm) with the rollers and to use the rolling patterns designated for this mix (see Figure 96).



Source: NCAT

Figure 96. Roller Compacting the Unconfined Joint over the VRAM Material

A shadow was noticeable in the area where the VRAM was placed under the joint.

The third pull covered the remaining 9 inches (23 cm) of the VRAM, beginning at approximately noon. The contractor allowed the edge of the joint to cool below 110 ºF (43 ºC) before starting this pull to create a "cold" joint over the VRAM.

The joint for the fourth and final pull was allowed to cool below 110 ºF (43 ºC) to create a "cold joint" at the location designated for the RPE application. Paving of the connector taxiway was completed by about 12:30 p.m. No flushing was noticed in the VRAM joint.

RPE Installation

The RPE was applied on Nov. 16, 2023, one day after the paving. The material was applied using a spray bar attached to a pickup truck (see Figure 97). The truck carried a circulating tank and a propane burner to heat and agitate the RPE material. Prior to application, the material was heated to 113 ºF (45 ºC) and continuously circulated within the tank. The RPE installation began at approximately 8:30 a.m., when the ambient temperature was 62 ºF (16 ºC), and the joint surface was 71 ºF (21 ºC).



Source: NCAT

Figure 97. Pickup Truck-Mounted Spray Bar Used for the RPE Application

Two locations were selected and prepared for the RPE installation. RPE Location A was along the crossover taxiway adjacent to the VRAM installation. This location was constructed using a cold butt joint, with no cutback of the unconfined edge, followed by the RPE application. RPE Location A was approximately 250 ft (76 m) long and adjacent to the location where the VRAM was installed. The target RPE application rate for Location A was 0.15 gal/yd^2 (0.68 L/m^2) at a width of 24 inches (61 cm), which was verified during the application. The material penetrated quickly and broke within 15 min. The RPE was non-tracking within 30 min of application, even in shaded areas. Figure 98 shows the butt joint-treated with RPE.



Source: NCAT

Figure 98. RPE Application on the Butt Joint of the Crossover Taxiway

RPE Location B was along the main taxiway north of the crossover area (see Figure 99). This location used a cutback joint construction method, followed by the RPE application. This location was 540 ft (164 m) long, just north of where the crossover taxiway ties into the main taxiway. The target RPE application at this location was 0.08 gal/yd^2 (0.36 L/m^2) at the same width of 24 inches (61 cm). This material also broke and was non-tracking within 30 min.

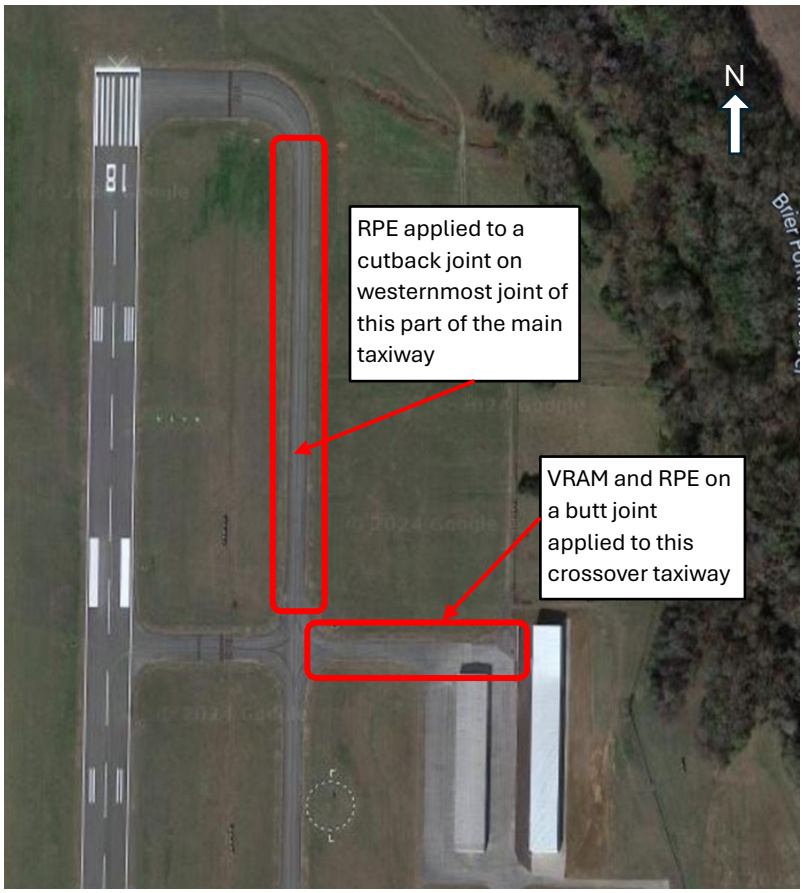


Source: NCAT

Figure 99. Cutback Joint Application of RPE on the Main Taxiway

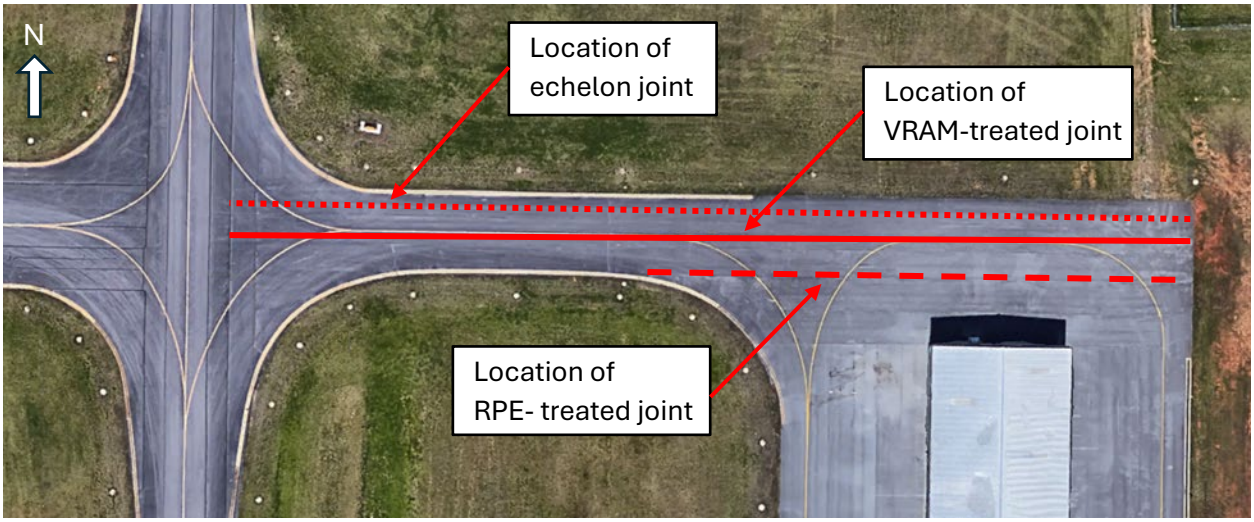
Application Locations

The applications of VRAM and RPE on this project will allow for easy monitoring of the performance of the longitudinal joint treatments over time. The applications of VRAM and RPE on a butt joint were on adjacent longitudinal joints of the northern crossover taxiway. An echelon joint was also constructed on a parallel longitudinal joint on that part of the taxiway. RPE was also applied to a section with a cutback joint on the adjacent, northernmost part of the main taxiway. An untreated cutback joint on this main taxiway was available as a control section. Figure 100 shows the locations of the VRAM- and RPE-treated longitudinal joints. Figure 101 shows the locations of the echelon-paved joint and the VRAM- and RPE-treated longitudinal joints.



Source: © Google® Maps

Figure 100. Locations of the VRAM- and RPE-Treated Longitudinal Joints



Source: © Google® Maps

Figure 101. Locations of the Echelon Paved Joint and the VRAM- and RPE-Treated Longitudinal Joints Along the Crossover Taxiway

Summary

The trial applications of VRAM and RPE were installed on taxiways at the Huntsville Executive Airport located in Meridianville, AL, on Nov. 14, 15, and 16, 2023. Three parallel longitudinal joint test sections were constructed on the northernmost crossover taxiway. The northernmost longitudinal joint is an echelon joint. The next longitudinal joint to the south is the VRAM application under a butt joint. This RPE section is shorter because the taxiway widens toward the eastern end as it nears the hanger area. RPE was also applied over a cutback joint on part of the main taxiway. The cutback joint RPE application is approximately 1/10th of a mile (161 m) on the westernmost joint of the main taxiway just north of the crossover.

The cores are labeled and stored at NCAT. No testing is planned for the cores at this time.

Moton Field Municipal Airport, Tuskegee, AL

Project Description

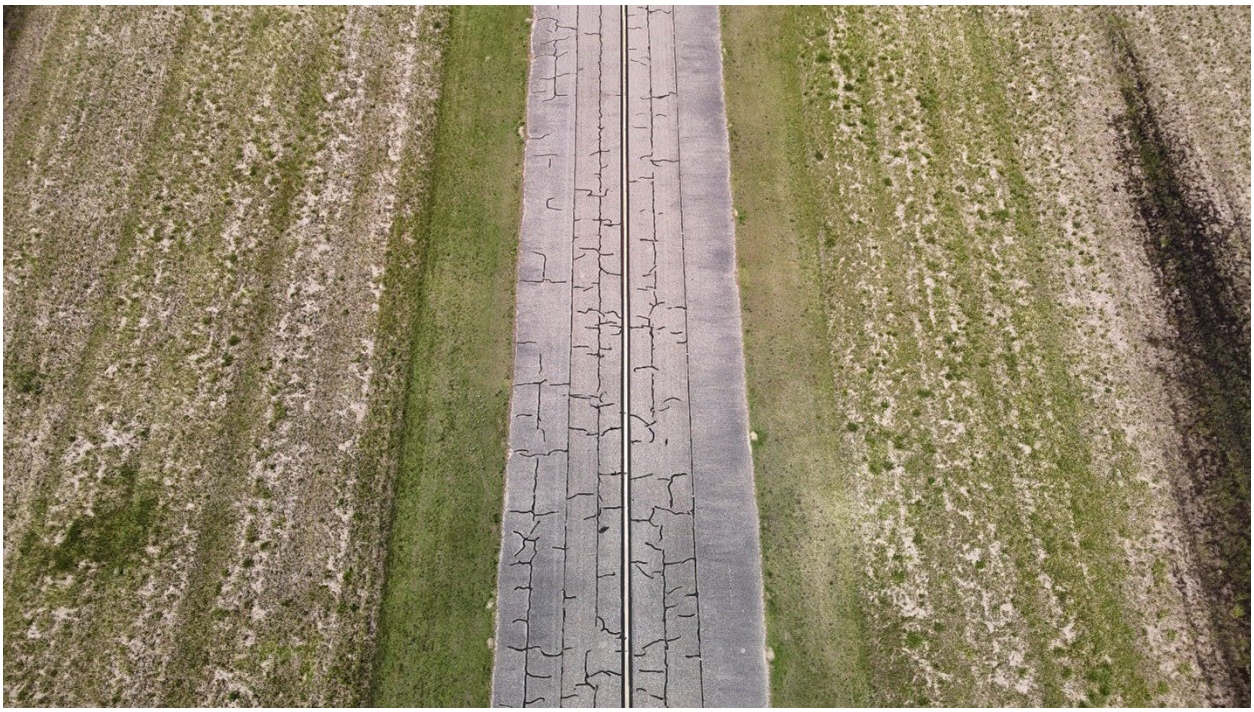
Moton Field Municipal Airport in Macon County, AL, is a public-use airport owned by the City of Tuskegee. The Tuskegee Airmen National Historic Site is located at Moton Field. Figure 102 shows an aerial photo of the airport before the taxiway rehabilitation in 2024.



Source: © Google® Maps

Figure 102. Aerial Photo of Moton Field Taken in May 2024 Prior to Taxiway Rehabilitation

The 2024 taxiway rehabilitation project included milling and repaving the taxiway and connectors. The main part of the taxiway is approximately 40 ft (12 m) wide and about 4,700 ft (1,432 m) long. Figure 103 shows a photograph of a section of the taxiway to illustrate the typical condition of the existing pavement before rehabilitation. It is evident that the taxiway had been previously paved in four lanes, resulting in a longitudinal joint at the centerline of the runway, a longitudinal joint between the two lanes left of the centerline, and another longitudinal joint between the two lanes right of the centerline. NCAT took aerial photographs and videos of the taxiway on April 16, 2024, to document the existing pavement condition for future reference. Block cracking, mid-lane longitudinal cracking, and longitudinal joint cracks throughout the taxiway were last sealed in 2019.



Source: NCAT

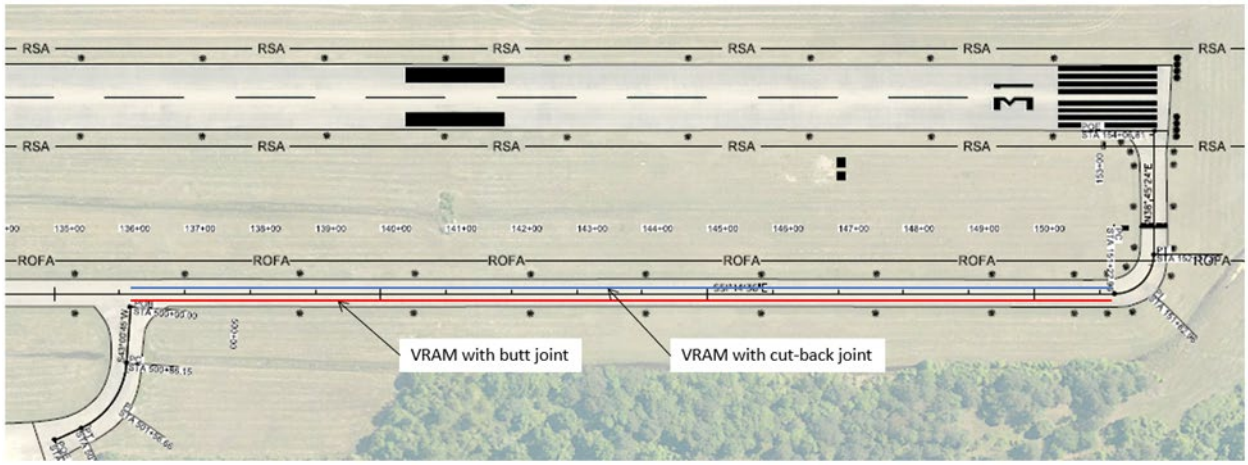
Figure 103. Photo of a Portion of the Taxiway Illustrating Typical Condition Prior to Rehabilitation

As part of the rehabilitation project, six longitudinal joint treatments (i.e., six test sections) were used in three different sections (east, middle, and west) of the taxiway, as summarized in Table 18 and in Figure 104 through Figure 106. Each test section was approximately 1,500 ft (457 m) long. The paving work was conducted by Wiregrass Construction Company in April 2024. Asphalt Materials, Inc. applied the VRAM at the time of the paving. They returned in June to apply the RPE. Specifications for VRAM and RPE are included in Appendix A.

Table 18. Longitudinal Joint Treatments Constructed on Moton Field

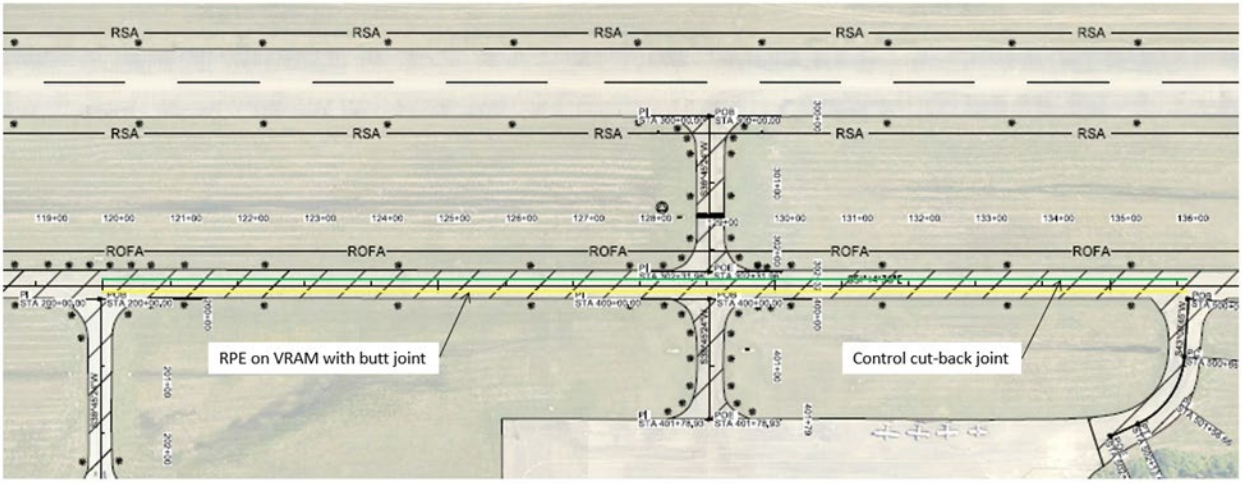
Section	Longitudinal Joint Treatment	Starting GPS	Ending GPS
East	VRAM with a cutback joint	32.458264, -85.678330	32.455698, -85.674552
	VRAM with a butt joint	32.458246, -85.678383	32.455670, -85.674606
Middle	Control cutback joint	32.461071, -85.682433	32.458264, -85.678330
	RPE on VRAM with a butt joint	32.461030, -85.682470	32.458246, -85.678383
West	RPE on a cutback joint	32.464045, -85.686757	32.461071, -85.682433
	RPE on a butt joint	32.464001, -85.686805	32.461030, -85.682470

Note: GPS = Global Positioning System



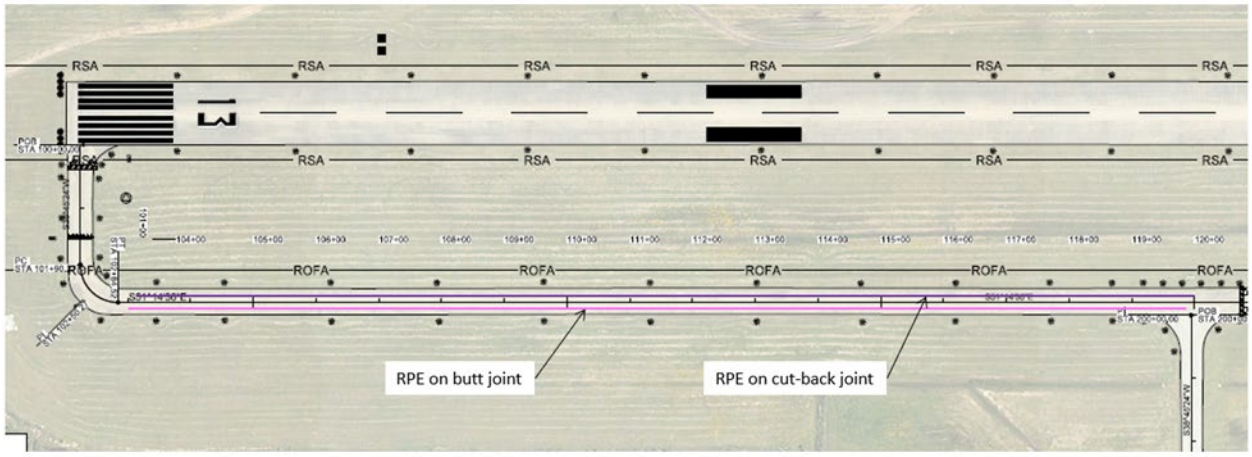
Source: NCAT

Figure 104. Longitudinal Joint Construction Method at the East Section



Source: NCAT

Figure 105. Longitudinal Joint Construction Method at the Middle Section



Source: NCAT

Figure 106. Longitudinal Joint Construction Method at the West Section

Site Visit

NCAT researchers visited the construction site during the installation of VRAM and paving operations. The existing distressed surface was previously milled for the construction of the overlay. Transverse cracking was observed in some portions of the milled surface, as shown in Figure 107. The VRAM was applied on the "VRAM with a cutback joint" section on April 23, 2024, and the "VRAM with a butt joint" section on April 24, 2024.



Source: NCAT

Figure 107. Transverse Cracking on the Milled Surface

VRAM Application

The contractors used a Cimline MA4 system to apply the VRAM, as shown in Figure 108. Initially, a CRS-1 tack coat was applied to the milled surface of the taxiway. The VRAM was then applied on the milled surface where the longitudinal joint of the lanes of the surface layers were to be paved.

The application process of the VRAM application was different for cutback and butt joints. The application of "VRAM with a cutback joint" was completed in two applications. In this case, a 9-inch (22-cm)-wide application of VRAM was applied followed by paving of the first lane with the mat width extending approximately 3 inches (7 cm) past the edge of the VRAM. After compaction of the first lane, the 3-inch (7-cm) part of the mat was then cut back and removed, After the 3-inch (7-cm) part of the first lane was removed and the cut edge cleaned, the adjacent lane was prepared by applying the tack coat, then the second half (9-inch [22 cm] width) of VRAM was applied to the milled surface against the cut edge of the first lane. For the "VRAM with a butt joint" section, the VRAM was applied at a width of 18 inches (45 cm) centered under where the longitudinal joint of the lanes of the surface layers was to be paved. The VRAM with a butt joint method involved a much simpler and faster process.

The contractors conducted a test shot of the VRAM application to check the application rate and width, as shown in Figure 109. The test appeared to be satisfactory, and the application of VRAM proceeded at 10.05 a.m. Figure 110 and Figure 111 show VRAM applied for the "VRAM with a cutback joint" and "VRAM with a butt joint" sections, respectively. The VRAM temperature was approximately 310 °F (154 °C) while applied. An application rate of 1.0 gal/yd^2 (4.5 L/m^2) was maintained, as recommended by Asphalt Materials, Inc. for a milled surface. A bond breaker, typically a mixture of water and fabric softener, was applied after the VRAM installation, as shown in Figure 112 and Figure 113. The edge of the VRAM application was marked (see Figure 114), which helped maintain the paving width during paving and cutting back.



Source: NCAT

Figure 108. VRAM Application Equipment



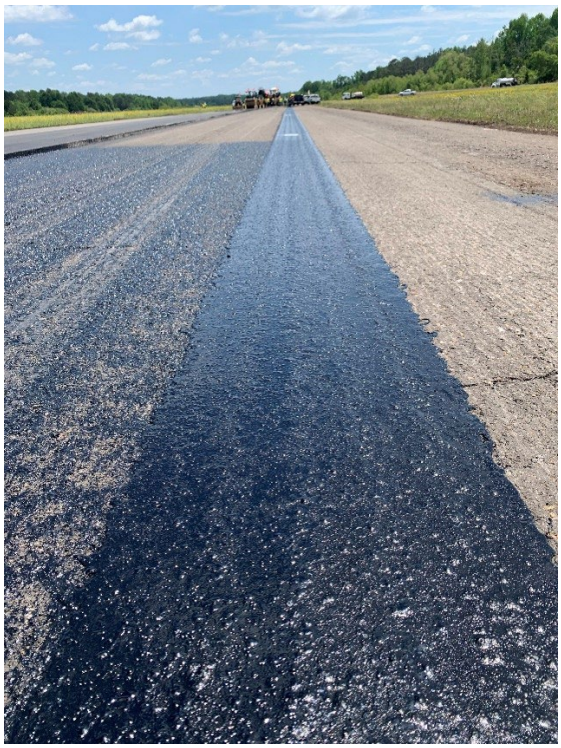
Source: NCAT

Figure 109. Test Shot of VRAM Application



Source: NCAT

Figure 110. VRAM Applied (9-inch [22-cm] width) for the Cutback Joint



Source: NCAT

Figure 111. VRAM Applied (18-inch [45-cm] width) for the Butt Joint



Source: NCAT

Figure 112. Applying Bond Breaker (Water plus Fabric Softener) on the VRAM for the Cutback Joint



Source: NCAT

Figure 113. Applying Bond Breaker (Water plus Fabric Softener) on the VRAM for the Butt Joint



Source: NCAT

Figure 114. Marking the Edge of the VRAM for the Cutback Joint

Paving Operations and Compaction

The paving operation started immediately after the VRAM strip was marked. As mentioned earlier, paving was conducted on the milled taxiway surface with CRS-1 tack coat applied to the entire taxiway and the VRAM on the longitudinal joint. Figure 115 shows the prepared taxiway surface treated with tack coat and VRAM on the joint before the paving operation. Figure 116 shows the paving operation.

Some difficulties were observed during the paving of the first lane for the cutback joint with VRAM. As the paver moved over the VRAM strip, the tires under the paver hopper picked up VRAM, as shown in Figure 117. The contractors removed the tracked VRAM from the tires (see Figure 118), and an additional bond breaker was sprayed on the VRAM to prevent this difficulty, as shown in Figure 119. This problem was not encountered during the construction of the butt joint with VRAM (see Figure 120).

Two types of rollers, a breakdown roller (vibratory steel wheel) and a finish roller (static steel wheel), were used for compaction. The rollers overhung the unconfined edge by 6 to 12 inches (15 to 30 cm) during compaction in both cutback and butt joints (see Figure 121). A rolling pattern was followed to ensure a target density of 94.5 percent at the mat and 92.5 percent at the longitudinal joint sections. The density of the mat was monitored by the contractor using a nuclear gauge, as shown in Figure 122.

For the cutback operation, the contractor initially tried a cutting wheel attached to a motor grader. However, the contractor changed to a cutting wheel attached to a steel-wheeled roller, as shown in Figure 123, and this provided a straighter cutback joint.



Source: NCAT

Figure 115. Prepared Surface (VRAM and CRS-1 Tack Coat Applied) for Paving Operation



Source: NCAT

Figure 116. Paving Operation



Source: NCAT

Figure 117. Paver Tire on the VRAM Strip (Cutback Joint)



Source: NCAT

Figure 118. Cleaning VRAM Picked Up on the Paver Tire (Cutback Joint)



Source: NCAT

Figure 119. Spraying the Bond Breaker on the VRAM



Source: NCAT

Figure 120. Paving Operation for the Butt Joint



Source: NCAT

Figure 121. Compacting the Unconfined Edge of the Mat over the VRAM Strip



Source: NCAT

Figure 122. In-place Density Measurement for Quality Control

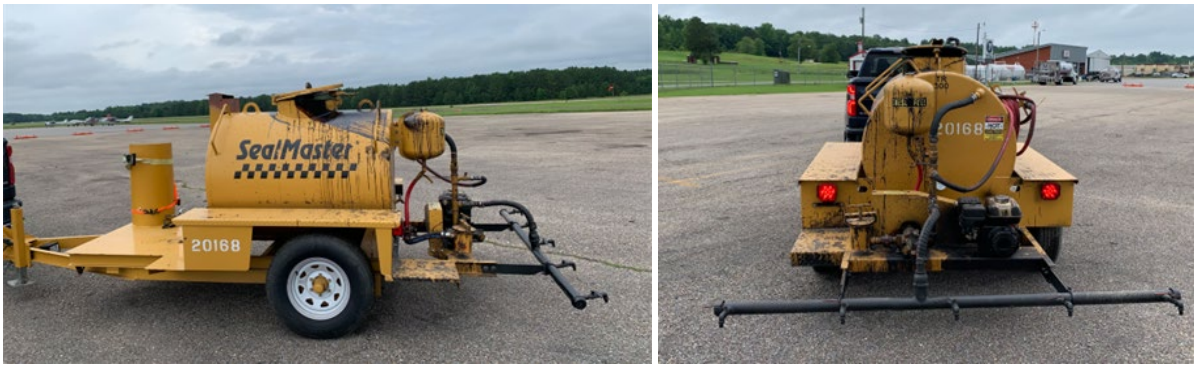


Source: NCAT

Figure 123. Cutting Wheel Attached to a Steel-Wheeled Roller

RPE Installation

The RPE was applied on June 4, 2024. As mentioned earlier in Table 18, the RPE was applied in three sections: RPE on VRAM with a butt joint in the middle section of the taxiway, RPE on a cutback joint, and RPE on a butt joint in the west section of the taxiway. NCAT researchers observed the RPE application. The RPE was applied using SealMaster spraying equipment, as shown in Figure 124. Prior to the application, the RPE was heated to 116 °F (46 °C) and continuously circulated within the tank. The application of the material started at approximately 9 a.m. Figure 125 shows the RPE spraying operation.



Source: NCAT

Figure 124. SealMaster Spraying Equipment for RPE



Source: NCAT

Figure 125. RPE Spraying Operation

The application of RPE was started on the VRAM with a butt joint section and proceeded continuously to the end of the west section, covering both VRAM with a butt joint (middle section) and the RPE on a butt joint (west section) in a single operation. Figure 126 and Figure 127 show the applied RPE on the VRAM with butt joint and butt joint (no VRAM) sections, respectively. In the second operation, the RPE was applied on the cutback joint from the west section to the middle section (see Figure 127). The application rate of

0.15 gal/yd^2 (0.68 L/m^2) at a width of 20 inches (50 cm) was maintained for the RPE application in all the sections. The RPE broke and penetrated quickly into the joints, which can be observed in Figure 128. The application was completed at approximately 9:40 a.m. NCAT researchers sampled a few gallons of RPE from the site for potential laboratory evaluation of RPE.



Source: NCAT

Figure 126. RPE Applied on a VRAM with a Butt Joint



Source: NCAT

Figure 127. RPE Applied on a Butt Joint (No VRAM)



Source: NCAT

Figure 128. RPE Applied on a Cutback Joint

Summary

The Moton Field (Tuskegee) Municipal Airport taxiway rehabilitation project completed in May and June 2024 provided an opportunity to construct six approximately 1,400-ft (426-m) longitudinal joint test sections for future long-term performance evaluations. The six longitudinal joint test sections included (1) a standard FAA P-401 cutback joint (control section), (2) a section with VRAM applied before a cutback joint, (3) a section with VRAM applied before a conventional butt joint, (4) a cutback joint followed by an application of RPE, (5) a section with VRAM applied before a cutback joint and RPE applied after construction, and (6) a butt joint with RPE applied after construction. The most challenging and time-consuming test section was the second section because it required the application of VRAM in two parts, with cutting back the joint before the second half of the VRAM application. Since the lanes were relatively narrow (10 ft [3 m]), the paver wheels had to track over the VRAM application, and that initially caused the VRAM to pick up on the tires. This problem was resolved with a heavier application of the bond breaker.

Summary of New Project Inspections

As part of this research project, three new airport rehabilitation projects were visited to monitor and document the application of longitudinal joint treatments that included VRAM and RPE.

The Central Kentucky Regional Airport runway rehabilitation project, completed in July 2024, utilized three construction techniques to address joint deterioration in airport pavements: echelon paving, cutback joints, and VRAM.

The Huntsville Executive Airport taxiway reconstruction project, completed in November 2024, utilized three longitudinal joint treatments: VRAM without cutting back the unconfined side of the longitudinal joint, RPE without cutting back the longitudinal joint, and RPE on a traditional airfield cutback longitudinal joint.

The Moton Field (Tuskegee) Municipal Airport taxiway rehabilitation project, completed in May and June 2024, provided an opportunity to construct six longitudinal joint test sections. The test sections included (1) a standard FAA P-401 cutback joint (control section), (2) a section with VRAM applied before a cutback joint, (3) a section with VRAM applied before a conventional butt joint, (4) a cutback joint followed by an application of RPE, (5) a section with VRAM applied before a cutback joint and RPE applied after construction, and (6) a butt joint with RPE applied after construction.

For one project, some difficulties were observed during the paving of a lane with a cutback joint. Specifically, as the paver moved over the VRAM strip, it picked up on the tires under the paver hopper. The contractors removed the tracked VRAM from the tires, and an additional bond breaker was sprayed on the VRAM to prevent this difficulty. This was the only project where this issue was encountered.

Although not included in the scope of this project, monitoring these field projects to assess the performance of the different longitudinal joint construction techniques will be of significant value in making recommendations to the FAA regarding effectiveness and potential implementation.

Appendix A. Examples of VRAM and RPE Specifications

Void Reducing Asphalt Membrane (VRAM)

DESCRIPTION

This Work consists of applying a void reducing asphalt membrane (VRAM).

The VRAM is applied underneath the longitudinal construction joint(s) as shown on the typical sections, prior to paving the final lift of a hot-mix asphalt (HMA) pavement.

MATERIAL

Provide void reducing asphalt membrane meeting the criteria in Table 1. Add Elastomers to the base asphalt. Use either a styrene-butadiene diblock or triblock copolymer.

TABLE 1 – VOID REDUCING ASPHALT MEMBRANE CRITERIA

TEST	CRITERIA	TEST METHOD
Dynamic shear @ 88°C (unaged), G*/sin δ	1.00 kPa minimum	AASHTO T 315
Creep stiffness @ -18°C (unaged) Stiffness (S) m-value	 300 MPa maximum 0.300 MPa minimum	AASHTO T 313
Ash, %	1.0% - 4.0%	AASHTO T 111
Elastic Recovery, 100 mm elongation, cut immediately, 25°C	70% minimum	ASTM D6084 method A
Separation of Polymer, difference in ring and ball+	3°C maximum	ASTM D7173

CONSTRUCTION REQUIREMENTS

A. Equipment.

1) Distributor

Provide a distributor capable of applying Material at the specified application rate and width. Apply the VRAM in a single pass.

2) Melter kettle

Provide a melter kettle capable of applying Material at the specified application rate and width. Apply the VRAM in a single pass. Material from the kettle may be dispensed through a pressure feed wand with an applicator shoe or with a spray bar. Use an oil jacketed double-boiler type with agitating and recirculating systems.

B. Material Handling.

Provide the Engineer with one copy of the manufacturer's recommendations for heating, re-heating, and applying the void reducing asphalt membrane at the pre-construction meeting.

C. Void Reducing Asphalt Membrane Application.

Clean the pavement surface by sweeper/vacuum truck, power broom, or air compressor.

Apply VRAM to a clean and dry surface. Apply the VRAM within 2 inches of the project established centerline or established lane edge. Use a stringline or paint mark as a guide for the application to maintain a uniform edge alignment. When only one-half of the joint is exposed, such as a mill and inlay project, apply one-half the prescribed width, adjacent to the center of the joint, and coat the vertical face of the cold joint left in place.

Apply the VRAM in a single pass placed by any application method listed in the Equipment section. VRAM application temperature shall not exceed 330°F. Apply the VRAM at a width of 18" plus or minus 1.5", or at 9" plus or minus 1". If the width is outside that tolerance, stop placement of the VRAM and take remedial action. Apply the VRAM to the existing surface prior to the tack coat applications. VRAM may be applied over fully cured tack.

Construction traffic should be able to drive on the VRAM without pick up or tracking, within 30 minutes of placement. Placement of the VRAM will stop and take remedial action if pick up or tracking occurs. Ensure the paver end plate and grade control device are not in contact with the VRAM.

Determine the application rate of VRAM based on the maximum aggregate size of the mixture. Apply the VRAM, in conformance with Table 2.

TABLE 2 – VRAM APPLICATION

Aggregate Size B (-3/4")		
HMA Thickness, inch	**VRAM Width, inch**	**Application Rate, pounds per foot**
1 ½	18	1.47
1 ¾	18	1.63
≥ 2	18	1.80
Aggregate Size A (-1/2")		
HMA Thickness, inch	**VRAM Width, inch**	**Application Rate, pounds per foot**
≥ 1 ½	18	0.95
SMA Mixtures/SuperPave 5 Mixtures*		
HMA Thickness, inch	**VRAM Width, inch**	**Application Rate, pounds per foot**
1 ½	18	1.26
1 ¾	18	1.38
≥ 2	18	1.51

Notes.

*In the event of a joint between two different mixes, use the lower application rate.

Exclude the area 1.0 ft on either side of the longitudinal joint from density measurement and pay adjustment.

Check the application rate of VRAM within the first 1,000 linear feet of the day's application length and every 12,000 linear feet the remainder of the day. Check the rate twice for projects less than 12,000 feet in length. Check the rate by weight per foot. Place a paper or pan at a random location in the path of the VRAM application. Pick up and weigh the paper or pan after application of the VRAM. Calculate the weight per foot. Replace the VRAM in the area where the application rate was checked. The tolerance for the Plan target weight per foot from the VRAM Application Rate Table is ± 10%. Re-apply VRAM in any areas that are deficient by more than 10% of the required application rate.

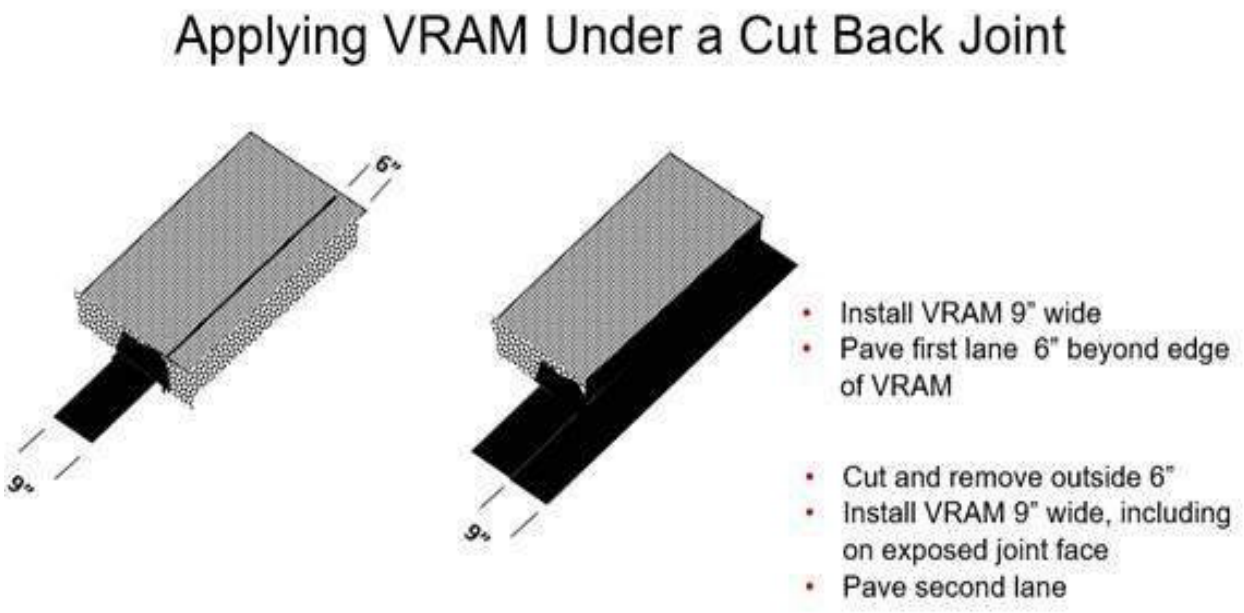


FIGURE 1 – VRAM APPLICATION

D. Quality Control / Quality Assurance

Acceptance of the VRAM is based on the certification by the manufacturer that the material meets the requirements listed in Table 1 – void reducing asphalt membrane. Field sampling will be used to verify that the delivered VRAM meets the requirements of the specification. The Contractor shall take a sample from the spray bar or applicator shoe during the first 20 minutes of placing VRAM on the Project. After the first sample is taken sample for every 25,000 gallons of material used on the project.

Sample in the presence of the Engineer.

Each sample shall consist of a one quart aluminum or steel sample containers. Labeled the sample container with SP number, date, time, location, manufacturer, and BOL number of the sealant.

METHOD OF MEASUREMENT

The Engineer will measure the VRAM by the linear foot for both full width.

BASIS OF PAYMENT

A. Payment. The work covered by this section shall be paid for by linear foot. This shall be full compensation for furnishing all materials and for all preparation, hauling, and placing of the material and for all labor, equipment, tools, and incidentals necessary to complete this item.

PLANS	Void Reducing Asphalt Membrane (no cutback) - per linear foot
PLANS	Void Reducing Asphalt Membrane (with cutback) - per linear foot

END OF ITEM VRAM

RAPID PENETRATING EMULSION (RPE) CENTERLINE SPECIFICATION GUIDELINE

DESCRIPTION

This specification covers the requirements and practices for applying a rapid penetrating asphalt emulsion (RPE) at the surface of an asphalt pavement. The RPE may be applied along the longitudinal joint area of the asphalt pavement, or RPE may be applied across the full width of the asphalt pavement. This work shall be done according to the following Standard Specification except as modified herein.

MATERIAL

The type and grade of asphalt material shall be in accordance with the following table. The table includes test methods developed to measure surface penetration performance and its ability to resist water and/or re- emulsification.

Tests on Emulsion	**Test Method**	**Test Requirement**
Viscosity, 25C, SFS	AASHTO T72	50 max
Sieve test, %	AASHTO T59	0.1 max
Identification test*, %	ITM	60 min
Water resistance test**, %	ITM	60 min
Residue by distillation***, %	AASHTO T59	30 min
Oil in distillate by volume of emulsion	AASHTO T59	1.0 max

Tests on Residue	**Test Method**	**Test Requirement**
Penetration, 25C, 100g, 5s, dmm	AASHTO T49	150 max
Solubility in trichlorethylene, %	AASHTO T44	97.5 max

*Test Method for Identification of Penetrating Emulsified Asphalts (See Appendix A)
**Test Method for Curing and Water Resistance by Mass Retention of Emulsified Asphalts (See Appendix A)
***300g of emulsion may be used to obtain enough residue for residue testing

CONSTRUCTION REQUIREMENTS

A pressure distributor shall be provided that is capable of applying RPE within a certain range of application rates. The distributor shall be capable of recirculating material for mixing and agitation purposes. The distributor shall be capable of heating the RPE to a temperature of at least 180 degrees Fahrenheit. The distributor shall be equipped with appropriate spray nozzles for the specified application rates and provide uniform coverage.

The contractor may use a portable storage unit or transfer trailer with mixing and heating capabilities to transport larger quantities of material to the job site.

A. **Preparation of Surface.**

Prior to the application of the RPE, the Engineer shall ensure the application area is free of debris and surface moisture. The Engineer will determine if the moisture under the surface will delay construction based on the amount of and time since the last rain. The area may be cleaned by sweeper/vacuum truck, power broom, air compressor or hand to the satisfaction of the Engineer.

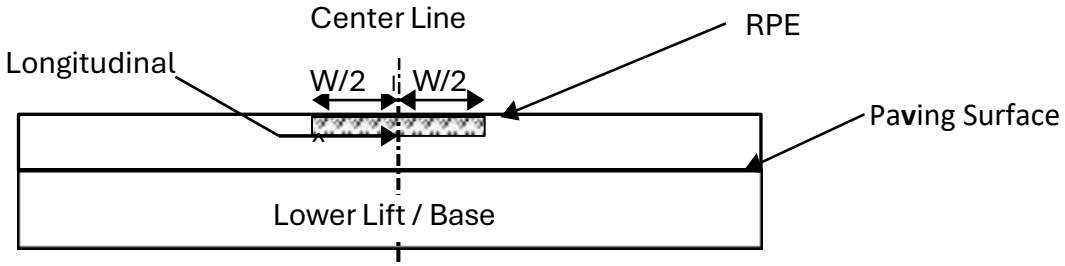
B. **Application of RPE.**

The application is designed to be over the longitudinal joint area at the width and tolerance specified below, or across the full width of the pavement with a specified overlap width and tolerance across the longitudinal joint, also discussed below.

The longitudinal joint application shall be sprayed 24 inches wide within +/- 2 inches of centerline at a rate of 0.15 +/- 0.01 gallon per square yard.

For sealing joints with milled corrugations, the application rate shall be reduced to 0.11 +/- 0.01 gallons per square yard.

Material may be dispensed through a pressure feed hand wand attached to a portable storage unit or pressure distributor provided temperature is maintained and application rate can be accurately measured.



C. **Acceptance.**

Provide a Bill of Lading to the Engineer for every tanker or distributor supplying material to the project.

The application rate of RPE on the longitudinal joint area will be checked within the first 1,000 linear feet of a

day's application. For a centerline-only application, the rate will be checked directly overlapping the joint using a suitable pan or pad. The rate will be checked by gallons per square yard. The rate shall fall within the tolerances specified in the construction section.

The Engineer may elect to measure the permeability constant in specified locations before application of the RPE and may elect to measure the permeability constant in the same location once the RPE has fully cured. The Engineer may elect to measure the texture depth using ASTM E965 (Sand Patch Method), ASTM E2157-15 (Circular Track Meter), or ASTM E2380 (Outflow Meter) before application and measure the texture depth once the RPE has fully cured in the same location.

METHOD OF MEASUREMENT

The Engineer will measure the longitudinal joint application with RPE by the linear feet.

BASIS OF PAYMENT

A. Payment. The work covered by this section shall be paid for by linear foot. This shall be full compensation for furnishing all materials and for all preparation, hauling, and placing of the material and for all labor, equipment, tools, and incidentals necessary to complete this item.

PLANS RPE, longitudinal joint - per linear foot

Cost association with calibration testing is to be included in the pay items. The cost determination of asphalt material rates, sweeping, and other incidentals shall be included in the cost of the pay items.

APPENDIX A

IDENTIFICATION TEST METHOD "A"

Identification of Penetrating Emulsified Asphalts

1. **SCOPE.**

1.0 This test method, applicable to both anionic and cationic emulsified asphalts, can be used as an identification test of the emulsions ability to penetrate a compacted asphalt mixture or a granular aggregate material.

1.1 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2. **REFERENCES.**

ASTM Standards.

E 11 Specification for Wire Cloth and Sieves for Testing Purposes

D 6934 Test Method for Residue by Evaporation of Emulsified Asphalt

D 6997 Test Method for Distillation of Emulsified Asphalt

3. **TERMINOLOGY.** Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.
4. **SIGNIFICANCE AND USE.** ITM is used to identify or classify an emulsified asphalt as having a penetrating capability as measured by the amount of emulsified asphalt that can pass through a 500 wire sieve in a period of 5 minutes.
5. **APPARATUS.**

5.1 Wire Cloth Sieve, 3" round sieve, number 500 mesh (25 um).

5.2 Receiver/pan/can, metal container of size to collect emulsified asphalt passing the wire cloth sieve.

5.3 Balance, capable of weighing 500 ± 0.1 g.

5.4 Water bath, constant temperature, maintained at 50 ±0.5C

5.5 Oven, capable of maintaining a temperature of 50 ± 3C.

5.6 Thermometric Device, thermometer 15C or 15F as prescribed in Specification E 1, or equivalent thermometric device.

5.7 Timer, capable of measuring time to ± 5 seconds.

6. **SAMPLING.** Sampling shall be as stated in the referenced ASTM methods.
7. **PREPARATION OF SAMPLE.**

7.1 All emulsified asphalts shall be properly stirred to achieve homogeneity before testing.

7.2 Warm the emulsified asphalt to 50 ± 3°C in an oven or water bath. After the sample reaches 50°C, stir the sample to achieve homogeneity.

8. **PROCEDURE.**

8.1 Warm the diluted emulsified asphalt to 50 ± 3°C in a water bath or oven.

8.2 Tare the receiver/pan. Assemble the 3" sieve and receiver/pan on the balance. Pour 20 ± 0.1 g diluted emulsified asphalt onto the sieve. Immediately after the emulsified asphalt is poured on the sieve, start the timer. After 5 minute ± 15 seconds, remove the sieve from the assembly. Record the mass in grams of emulsified asphalt retained in the receiver/pan.

8.3 Clean the sieve by rinsing with soft water to remove emulsion. Then wash with Acetone, followed by TCE to remove asphalt solids, and another washing with Acetone to remove any excess TCE and RPE chemicals. Air dry the sieve using a pressurized air hose until moisture is gone, and allow the sieve to return to room temperature before conducting another test.

9. **CALCULATION.**

9.1 Calculate the percent of emulsion passing the #500 sieve in 5 minutes as follows:

Mass retained in pan/20 x 100 = % of emulsified asphalt passing #500 sieve

10. **REPORT.**

10.1 The average of three tests for % of emulsified asphalt passing the #500 sieve.

Standard Test Method for Mass Retention of Emulsified Asphalts Subjected to Water Droplets

1. SCOPE.

1.1. The method gives a measure of water resistivity and how quickly an applied asphalt emulsion can become water resistant. This test method is used to measure material runoff caused by a rain effect at different time intervals, allowing the method to measure differences in drying times between products of different formulations.

1.2. This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2. REFERENCES.

2.1. ASTM Standards:

2.1.1.D 6934 Test Method for Residue by Evaporation of Emulsified Asphalt

2.1.2.D 6997 Test Method for Distillation of Emulsified Asphalt

3. Terminology Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications

4. Significance and Use

4.1. This test method is used to measure the effects of secondary additives in Void Filling Emulsions or modified asphalt emulsions on the ability to dry quickly and become resistant to water droplets simulating rainfall.

5. Apparatus and Materials

5.1. *Receiver/pan* – Two large pans for collection of excess emulsion during application and water runoff during test.

5.2. *Water Release Device* – 100mL titration burette with stopcock, able to measure to tolerance of ±1mL.

5.3. *Balance* – capable of weighing 10±0.01g.

5.4. *Oven* – capable of maintaining a temperature of 50±3C

5.5. *Thermometric Device* – thermometer 15C or 15F as prescribed in Specification E 1, or equivalent thermometric device

5.6. *Timer* – Capable of measuring time to ±5 seconds

5.7. *Drying Apparatus* – wire rack or flat metal pan for drying at room temperature and in conditioning oven

6. Sampling. Sampling shall be as stated in the referenced ASTM methods.

7. Preparation of Sample.

7.1. All emulsified asphalts shall be properly stirred to achieve homogeneity before testing.

7.2. Warm the emulsified asphalt to 50 ± 3°C in an oven or water bath. After the sample reaches

50°C, stir the sample to achieve homogeneity.

7.3. All sandpaper strips should be measured and cut from 8.5"x11" sheets of red P50 grit sandpaper at room temperature.

7.4. For each trial, 4 strips should be cut to 5.5±0.1" tall by 2±0.1" wide with scissors. Label the top of these strips "A", "B", "C", and "D".

8. Procedure

8.1. Determine residue of the emulsified asphalt sample by distillation (Test Method D 6997) or evaporation for 3 h at 163 ± 3°C. (Test Method D 6934).

8.2. Fill titration burette full of RO water

8.3. Prepare your data collection table as shown in *Table 1.*

8.4. Record the dry weight of each sandpaper strips individually into the data table under *Measurement A* to the nearest 0.01g.

8.5. Lay the strips so they lean against the edge of the pan at an approximate 45-degree angle. Pour your sample across each of the strips, getting full coverage below the top half-inch.

8.6. Allow excess material to drip off the strips and immediately weigh each strip individually, recording under *Measurement B.*

8.7. Allow the strips to dry for 15 minutes. Position the strips in another collection pan below the titration burette. Be sure the burette tip is 1.5 ± 0.1 inches above the sandpaper strip.

8.8. Fully open the burette and drip 10 ± 0.5 mL of water onto the strip at full flow rate. Place the strip into the oven to cure for 2 hours. Repeat for the remaining strips.

8.9. Remove the strips from the oven and cool to room temperature. Weigh the final mass of the strip with dried residue and record under *Measurement C.*

9. Data Collection

Emulsion Name				**Start Time:**	Enter Start Time Here	**Tested Asphalt Residue Content**	Enter % Tested Residue Here (X%)		
Measurement	Trial 1	Trial 2	Trial 3	Trial 4		T1	T2	T3	T4
A =					Ra				
B =					Rc				
C =					%RRet				

Table 1: Data Collection Table

Where

A = Mass of dry sandpaper strip

B = Mass of sandpaper strip and applied material immediately after application

C = Mass of sandpaper strip and residue after 2 hours curing in 50°C oven

R_a = Residue applied before curing and water resistance test

R_c = Residue leftover after oven curing

$\%R_{Ret}$ = Percent Residue Retained

X = Tested Emulsion Residue percentage by distillation or evaporation

10. Calculations

$$Residue\ Applied = R_a = (B - A) * X$$

$$Residue\ After\ Oven\ Curing = R_c = (C - A)$$

$$\%\ \boldsymbol{Residue\ Retention} = \%\boldsymbol{R_{Ret}} = \frac{\boldsymbol{R_c}}{\boldsymbol{R_a}} * \mathbf{100\%}$$

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