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Pavement Preservation Demonstration Projects for Chip Seal and Microsurfacing Treatments

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Final Report VTRC 26-R02

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Abstract:

In 2021, the Virginia Department of Transportation (VDOT) collaborated with the National Cooperative Highway Research Program (NCHRP 20-44(26)) project research team to develop three specifications for chip seals, microsurfacing, and fog seals, incorporating recommendations from guidelines developed under the NCHRP 14-37 project and American Association of State Highway and Transportation Officials specifications. Subsequently, during the 2022 construction season, VDOT initiated two demonstration projects constructed under these new specifications. One project involved a chip seal application in the Richmond district, and the other project involved a microsurfacing application with a fog seal treatment on the shoulders in the Hampton Roads district. Each demonstration project included additional sections treated according to VDOT's current specifications, serving as reference sections for the corresponding demonstration sections.

The study assessed the effectiveness and performance outcomes of the demonstration sections constructed using the new specifications by comparing them with the reference sections constructed using the existing specifications. The effort included comprehensive documentation of preconstruction surface conditions and construction processes across project sections, incorporating qualitative visual inspections, quantitative measurements, and evaluations of material selection, application methods, and quality control measures. Furthermore, researchers assessed the short-term field performance of each section, monitored for up to 13 months, with performance metrics, such as texture, friction, rut depth, and ride quality.

The results indicated that the new chip seal specification did not lead to improved performance outcomes for the chip seal (demonstration) section compared with the chip seal (reference) section constructed using VDOT's current chip seal specification. Various factors affected the field performance of the chip seal treatment under the new specification, including challenges in achieving the target aggregate application rate and non-uniform spreading of aggregates during construction. In addition, differences in structural application, with one section featuring a modified single-layer chip seal application and the other a single-layer chip seal application, contributed to performance disparities. Further assessment through additional field trials is necessary to comprehensively evaluate the effectiveness of the new specification. Similarly, the new microsurfacing specification did not yield short-term performance differences for the microsurfacing (demonstration) section compared with the microsurfacing (reference) section constructed using VDOT's current microsurfacing specification.

The study recommends conducting additional field trials that include modified single-layer chip seal applications designed according to the new specification developed in this study to assess its effect on chip seal performance. In addition, the study recommends that VDOT should maintain the use of its current special provision for microsurfacing projects.

FINAL REPORT

PAVEMENT PRESERVATION DEMONSTRATION PROJECTS FOR CHIP SEAL AND MICROSURFACING TREATMENTS

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DISCLAIMER

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INTRODUCTION

The Virginia Department of Transportation (VDOT) is dedicated to preserving and improving the structural and functional integrity of existing pavements, ensuring these pavements remain in a state of good repair. In line with this operational objective, VDOT actively explores and, where viable, implements the latest advancements and best practices in pavement construction, including strategies for pavement preservation treatments, to continually improve practices. To this end, VDOT initiated a collaboration with the research team of National Cooperative Highway Research Program (NCHRP) project NCHRP 20-44(26) (TRB, n.d.). This collaboration focused on implementing guide specifications for the construction of chip seals, microsurfacing, and fog seals.

Building on this collaborative effort, in 2021, VDOT developed and published three specifications (referred to herein as "new specifications"), all which were specifically developed for these treatments, including a newly developed fog seal specification, for this study. The new specifications for chip seal and microsurfacing treatments represent an update that combines VDOT's current specifications with recommendations from guidelines developed under NCHRP Project 14-37 (Shuler et al., 2018) and American Association of State Highway and Transportation Officials (AASHTO) specifications (AASHTO, 2021). Specifically, VDOT used the following AASHTO standards to develop the specifications:

- M 340 *Standard Specification for Materials for Emulsified Asphalt Chip Seals*.
- R 102 *Standard Practice for Emulsified Asphalt Chip Seal Design*.
- M 341 *Standard Specification for Materials for Microsurfacing*.
- R 103 *Standard Practice for Microsurfacing Design*.
- M 343 *Standard Specification for Materials for Emulsified Asphalt Fog Seal*.
- R 105 *Standard Practice for Emulsified Asphalt Fog Seal Design*.

The new specifications for chip seal and microsurfacing treatments notably differed from VDOT's current specifications in terms of material and design requirements, as well as procedural protocols. Appendices A through E present both the current and new specifications for these treatments, with a detailed discussion of the differences included later in the report.

To evaluate the effect of these new specifications, VDOT conducted two demonstration projects during the 2022 construction season. These projects included a chip seal application in the Richmond district and a microsurfacing application with a fog seal treatment on shoulders in the Hampton Roads district. Each demonstration project was accompanied by sections treated in accordance with VDOT's current specifications that served as reference sections for the corresponding demonstration sections.

PURPOSE AND SCOPE

The purpose of this study was to evaluate the efficacy and effect of the newly developed specifications on the performance of chip seal and microsurfacing treatments. The scope of the study encompassed comparing current and new specifications, documenting preconstruction surface conditions and construction processes, and monitoring short-term field performance at the project sections.

METHODS

Four tasks were performed to achieve the study objectives:

1. Outlining the differences between VDOT's current and newly developed specifications for chip seal and microsurfacing treatments.
2. Documenting the preconstruction surface conditions of each project section.
3. Documenting the construction process for each project section.
4. Monitoring the short-term field performance of each project section.

Project Sites

The project site for the chip seal treatment was an approximately 3-mile stretch of Route 623 in Prince George County in the Richmond district. This section of the roadway is a two-lane undivided roadway with an average daily traffic volume ranging from 450 to 750 vehicles and a speed limit of 45 miles per hour (mph). The demonstration (demo) section included a single-layer chip seal treatment over a 0.9-mile stretch, and the reference section included VDOT's modified single-layer chip seal treatment for the remainder of section.

The project site for the microsurfacing treatment was an approximately 1.3-mile stretch of Route 132 in York County in the Hampton Roads district. This section of the roadway is a two-lane undivided roadway with an average daily traffic volume ranging from 6,000 to 10,000 vehicles and a speed limit of 45 mph. The demo section included a microsurfacing treatment in the northbound direction, and the reference section included VDOT's conventional microsurfacing treatment in the southbound direction, with a fog seal application on both shoulders. Table 1 presents location and traffic details for the projects.

Table 1. Site Information for the Projects

Project	Section	County	District	Route Name	Mile Post		ADT
					From	To	
Chip Seal	Reference	Prince George	Richmond	623	0.90	3.14	400–750
	Demo				0.0	0.90	
Microsurfacing	Reference	York	Hampton Roads	132	1.26	0.0	6,000–1,0000
	Demo				0.0	1.26	

ADT = average daily traffic; demo = demonstration.

Comparison of Specifications

The research team conducted comparative assessments between VDOT's current specifications and the new specifications for both chip seal and microsurfacing treatments. These assessments aimed to highlight the key areas where adjustments have been made to update the specifications for the pavement preservation treatments in accordance with the AASHTO standards.

Evaluation of Preconstruction Surface Conditions

The preconstruction surface conditions of each section were evaluated through both qualitative visual inspections and quantitative measurements, including macrotexture, rut depth, and ride quality assessments. In addition, pavement management system data were obtained for the microsurfacing sections. However, comparable data from recent periods were unavailable for the chip seal sections because these data are on a secondary route, where such data collection is less frequent or not routinely performed.

Documentation of Construction

The documentation of the construction process included observations on various aspects, including weather conditions during construction, the application process of the materials, properties of the materials used, and practices for measuring quality. This effort aimed to capture relevant details that could influence the overall performance of the sections.

Field Data Collection

The research team monitored the short-term performance of the field projects beginning shortly after the completion of construction. Surveys for macrotexture, rut depth, and ride quality measurements were conducted using a VDOT pavement profiler. The macrotexture measurements were quantified in terms of the mean profile depth (MPD) in accordance with ASTM E1845, *Standard Practice for Calculating Paving Macrotexture Mean Profile Depth* (ASTM International, 2021a). The rut depth measurements were collected in accordance with ASTM E1703, *Standard Test Method for Measuring Rut-Depth of Pavement Surfaces Using a Straight Edge* (ASTM International, 2021b). Researchers quantified ride quality measurements in terms of the international roughness index (IRI) in accordance with Virginia Test Method (VTM)-106, *Ride Quality Testing on Ride Specifications Projects – (Pavement Design)* (VDOT, 2001). In addition, macrotexture and skid resistance (friction) surveys were conducted using a Sideway-Force Coefficient Routine Investigation Machine (SCRIM®), following the methodology outlined in a previous study (Boz, 2024). The surveys were performed five times during the course of this study for the chip seal project and three or four times for the microsurfacing project, with exceptions for some projects due to machine- or field-related issues.

RESULTS AND DISCUSSION

Chip Seals

Comparison of Specifications

Table 2 outlines key differences between VDOT's current special provision and the new specification developed for the chip seal treatment in this study. The new specification presents notable differences, primarily in material and design requirements, but also in procedural protocols. The inclusion of traffic-based fracture and abrasion requirements for coarse aggregates, alongside a diversified range of gradation types, indicates a shift toward more tailored material selections that match the demands of different traffic levels. Procedural differences, such as enforcing a maximum surface temperature for placement, calibrating equipment closer to the time of application, checking for uniform aggregate application, and mandating the removal of existing pavement markings, aim to improve the consistency and quality of the pavement surface. In addition, the shift to the predominant use of pneumatic tire rollers with multiple passes, with an optional final pass using a steel wheel roller, aims to achieve improved surface texture with optimally embedded aggregates. Furthermore, the adoption of AASHTO R102 standard (AASHTO, 2021) for determining application rates aims to provide a better starting point than approximate or district-specific prescribed design application rates for single and modified single-layer chip seal treatments in VDOT specifications.

Table 2. Differences between VDOT's Current and New Provisional Specifications for Chip Seal Treatments

Section	Current	New
I. Description	—	—
II. Definition of Terms	—	—
III. Materials	Single value, aggregate-type dependent, fracture and abrasion requirements for coarse aggregates, irrespective of traffic level.	Traffic-based fracture and abrasion requirements for coarse aggregates in accordance with AASHTO M 340 (AASHTO, 2021)
	A single gradation type with a nominal aggregate size of 9.5 mm.	Four different gradation types as specified in AASHTO M 340 (AASHTO, 2021).
IV. Procedures	No maximum limit for surface temperature for placement.	A maximum surface temperature of 140°F for placement.
	Calibration for the equipment (emulsion distributor and aggregate spreader) to be performed in the presence of engineer prior to application.	Calibration for the equipment to be performed no earlier than 10 days prior to application.
	No requirements for checking on uniformity of aggregate application.	Checking uniformity of aggregate application transverse to the pavement centerline, in accordance with ASTM D 5624 (ASTM, 2017)
	No requirements for pavement marking removal.	Thermoplastic pavement marking removal prior to application.
	Use of a steel wheel roller and pneumatic tire roller for seating of aggregates for modified	Use of pneumatic tire rollers for seating of aggregates with a minimum of three roller

Section	Current	New
	and multicourse applications using CRS-2L emulsion (except the Bristol district, where only pneumatic rollers are allowed) and a minimum of two pneumatic tire rollers for a single-layer application. A minimum of one pass for each type of roller.	passes; final rolling may be accomplished using a steel wheel roller in one pass.
	Approximate range of application rates for single-layer chip seal applications, and district-specific prescribed application rates for modified single-layer and multicourse chip seal applications.	Use of AASHTO R 102 (AASHTO, 2021) for determination of application rates for single chip seal applications and the first layer application of modified single-layer chip seal applications.
V. Equipment	—	—
VI. Measurement and Payment	—	—

— = No difference. CRS-2L = Cationic rapid-setting, latex-modified.

Evaluation of Preconstruction Surface Conditions

Visual Evaluation

The reference and demo sections exhibited variations in preconstruction surface conditions. Both sections experienced minor raveling and bleeding issues throughout their lengths and instances of minor cracking. In addition, the reference section included areas of patches. Figures 1 and 2 illustrate examples of the preconstruction pavement surface conditions.

Figure 1. Areas of Patching (Left) and Instance of Cracking (Right) for the Reference Section

Figure 2. Areas of Minor Bleeding (Left) and Raveling (Right) for the Demonstration Section

Quantitative Evaluation

In addition to the visual surveys, the research team assessed preconstruction conditions of the sections through macrotexture, rut depth, and ride quality measurements. Friction data were not available for the preconstruction conditions. Preconstruction macrotexture levels, quantified in terms of MPD using VDOT's profiler, were statistically analyzed at a significance level of 5%. Unless otherwise noted, all statistical analyses performed in this study were conducted at 5%. The results indicated statistical similarity for both sections, with the reference section measuring 2.4 mm and the demo section measuring 2.7 mm.

Although the macrotexture levels measured from SCRIM differed from these levels when measured from VDOT's profiler, statistically similar values were obtained, with the reference section measuring 2 mm and the demo section measuring 1.9 mm. The disparity in macrotexture values measured by different equipment can be attributed to variations in data processing techniques (i.e., filtering methods). Such discrepancies in collected data were also observed in post-construction measurements, although the trends between data collected by the two different types of equipment were consistent.

Rut levels were relatively low and statistically similar for both sections, with the reference section measuring 0.15 inches and the demo section measuring 0.19 inches. Although variations in IRI values were also within a statistically similar range, these variations reflected notable differences in pavement smoothness between the two sections, with the reference section exhibiting a lower IRI of 177 inches per mile compared with the demo section's higher value of 251 inches per mile. In general, IRI values less than 70 inches a mile indicate a smooth pavement.

Documentation of Construction

The construction of the chip seal reference and demo sections commenced on April 8 and 6, 2022, respectively, with weather conditions conducive to chip seal applications, as outlined in both specifications. The construction of both sections was completed on the respective starting days.

The Reference Section

The reference section was treated with VDOT's modified single-layer chip seal application. For this section, CRS-2L emulsion was applied, and No. 8P and No. 9 aggregates were used for the first and second layers of the application, respectively. The target emulsion application rates were set at 0.17 gal/yd^2 and 0.15 gal/yd^2 for the first- and second-layer applications, respectively. Correspondingly, the target aggregate application rates were 15 lb/yd^2 for the first layer and 10 lb/yd^2 for the second layer.

Notably, VDOT's current specification prescribes fixed application rates for modified single-layer chip seals. The application sequence of materials and compaction procedures adhered to the specification. The application rates for the emulsion and aggregates were determined through a plate test, as per Section 312.04 of VDOT specifications. This test was carried out longitudinally, with no assessment made in the transverse direction. The results from the plate test indicated that the emulsion application rate measured at 0.18 gal/yd^2, which is slightly above the target rate of 0.17 gal/yd^2 for the first layer. Meanwhile, the aggregate application rate for the first layer was recorded at 8.9 lb/yd^2, substantially below the target rate of 15 lb/yd^2. No plate tests were conducted for the second layer of emulsion and aggregate applications. Figure 3 shows the finished surfaces of different segments in the reference section.

Figure 3. Completed Surfaces of Different Segments within the Reference Section after Chip Seal Application

The Demonstration Section

The demo section was treated with a single-layer chip seal application in accordance with the new specification. The same CRS-2L emulsion source used for the reference section was also applied to the demo section. Moreover, the same source and gradation of aggregates (No. 8P) employed for the first layer in the reference section were used in the demo section. The target emulsion application rate for the demo section was set at 0.32 gal/yd^2, and the target aggregate application rate was determined to be 16 lb/yd^2, measured in accordance with AASHTO R 102(AASHTO, 2021), as specified in the new VDOT specification.

Figure 4 shows the finished surface of segments with variable aggregate applications within the demo section. Although the application sequence of materials and compaction procedures conformed to the specification, researchers observed challenges with the aggregate spreader, which encountered difficulties providing uniform coverage across the transverse direction for one-half of the section (Figure 4a), but this issue was subsequently rectified (Figure 4b). During this process, the plate testing was exclusively conducted on the portion of the section that had non-uniform aggregate distribution and only in the longitudinal direction without any transverse direction checks. The plate test outcomes revealed that the emulsion application rate measured at 0.29 gal/yd^2, marginally below the target of 0.32 gal/yd^2. Conversely, the aggregate application rate for the first layer was documented at 11.7 lb/yd^2, which was significantly lower than the target of 16 lb/yd^2.

(a) **(b)**

Figure 4. Completed Surface of Segments within the Demonstration Section, Highlighting Variable Aggregate Applications after Chip Seal Application: (a) Uneven Initial Spreading by Aggregate Spreader; (b) Evenly Spread Aggregate

Material Properties

Samples of the emulsion and aggregates (No. 8P only) were taken from the project site for baseline material characterization and to verify the target (design) application rates. However, the aggregates used for the blot layer in the reference section were not included in this evaluation.

The residual asphalt content of the emulsion, determined following AASHTO T 59 (AASHTO, 2021), Section 7, was found to be 66.1%, which is above the minimum specification requirement of 65% for both specifications. The emulsion residue performance was graded according to AASHTO M 37 (AASHTO, 2021). The recovery of the emulsion residue adhered to AASHTO R 78 (AASHTO, 2021), Method B. High-temperature performance grade (PG) of the as-recovered emulsion residue was conducted in accordance with AASHTO T 315 (AASHTO, 2021). Concurrently, low-temperature PG was performed in accordance with AASHTO T 313 (AASHTO, 2021) on the as-recovered emulsion residue after aging this residue in the pressurized aging vessel following AASHTO R 28 (AASHTO, 2021). The results from these tests confirmed that the emulsion used in the projects satisfied the criteria for a PG 67-25 emulsion (residue), assuming PG 67-25 to be an appropriate PG for emulsions used in chip seal applications in Virginia, confirming the suitability of the emulsion used in these projects.

The aggregate was assessed for compliance with specifications across several properties, including particle size distribution (gradation), specific gravity, unit weight, voids in unit volume, and flakiness ratio. Sieve analysis was conducted for coarse aggregate per AASHTO T 27 (AASHTO, 2021) and for material finer than 0.075 mm (No. 200 sieve) per AASHTO T 11 (AASHTO, 2021). The bulk specific gravity of the aggregates was determined following AASHTO T 85 for coarse aggregate only. The standard test method described in AASHTO T 19 (AASHTO, 2021) was used to determine the bulk density (unit weight) and voids in unit volume of the aggregates. The flakiness index test was conducted in accordance with the procedure adopted by the Minnesota Department of Transportation for chip seal aggregates, the details of which can be found in a previous study (Boz, 2024). Finally, the abrasion resistance of the aggregates was determined in accordance with AASHTO T 96 (AASHTO, 2021). As shown in Table 3, the aggregate used for the first layer of the reference and demo sections met the boundary sieve size requirements specified in both specifications, confirming the suitability of the aggregate used in these projects.

Table 3. Gradation for the No. 8P Aggregate

Sieve	% Passing	Gradation Requirements	
		Current	New
1/2 inch	100	100	100
3/8 inch	94.4	75–100	90–100
No. 4	25.2	10–30	5–30
No. 8	1.7	Maximum 5	Maximum 10
No. 16	0.4	—	—
No. 30	0.2	—	Max. 2
No. 50	0.1	—	—
No. 200	0.1	Maximum 1.5	Maximum 1

— = not specified.

Table 4 presents the properties of the aggregates measured during this evaluation. The initial three properties listed in Table 4 serve as input parameters for calculating the application rate of an emulsion, as outlined by AASHTO R 102 (AASHTO, 2021). The final two properties in Table 4 correspond to the criteria specified in AASHTO M 340 (AASHTO, 2021) for durable chip seal performance. The collected data indicate that the aggregate used was appropriate for high-volume traffic conditions, characterized by an annual average daily traffic exceeding 2,500 vehicles.

Table 4. Properties of the No. 8P Aggregate

Properties	Measurement
Bulk specific gravity	2.654
Voids in Loose Aggregate, %	43.9
Loose Unit Weight, kg/m^3	1,453.6
Flakiness ratio, %	23.8
Abrasion loss, %	28.0

The emulsion and aggregate application rates for the demo section were determined in accordance with AASHTO R 102 (AASHTO, 2021) to verify the design application rates determined prior to the treatment. The application rates for the emulsion and aggregates were measured at 0.29 gal/yd^2 and 17.5 lb/yd^2, respectively. These measured values are within the range of measurement variability of the design (target) application rates that were set during the design phase for the demo section.

Field Performance

The literature shows that macrotexture can be used to serve as a key indicator for assessing the performance of chip seals in relation to prevalent modes of distress and construction quality (Adams and Kim, 2014; Aktas et al., 2011; Boz et al., 2018, 2019; Chaturabong et al., 2015; Gransberg, 2007; Gurer et al., 2012; Roque et al., 1991; Seitllari and Kutay, 2018; Shuler et al., 2011; Transit New Zealand, 2005). In New Zealand, a macrotexture depth of 0.9 mm after 1 year in service is used as a benchmark for deciding when to retreat chip seal projects (Transit New Zealand, 2005). The percent reduction in macrotexture is associated with the degree of aggregate loss and the occurrence of bleeding distresses (Adams and Kim, 2014; Chaturabong et al., 2015). Moreover, macrotexture, alongside the average least dimension of aggregates, is used to determine the percentage of aggregate embedment depth in chip seals, a calculation that is particularly relevant for single-layer chip seal applications (Shuler et al., 2011).

Figure 5 shows the average MPD measurements for both chip seal reference and demo sections, captured at various post-construction intervals, as well as preconstruction. The data were collected using VDOT's profiler and represents average values along the length of each section, specifically from the left wheel path of the profiler in the eastbound direction. As discussed previously, the preconstruction MPD of the demo section was marginally higher than that of the reference section, although the difference was not statistically significant. During the course of the study period, a consistent decline in MPD was observed for both sections, which is typical for chip seal surfaces because these surfaces experience wear and gradually embed into the pavement because of traffic. Approximately 1 year after construction, the MPD for the reference section measured 1.2 mm, and the demo section displayed a slightly smoother texture, with an MPD of 1.1 mm. The data indicate that both sections performed similarly, with small variations potentially attributable to the natural variability inherent in such measurements.

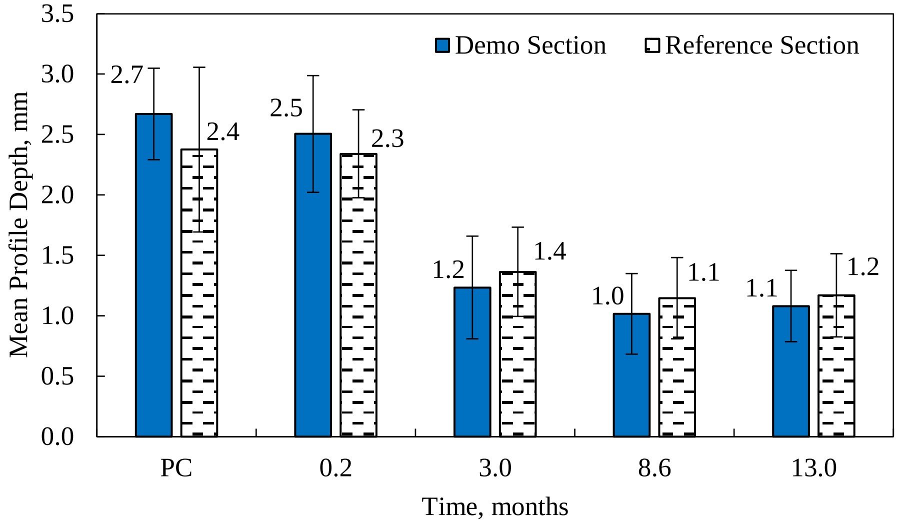

Figure 5. Average Mean Profile Depth Measurements for Chip Seal Reference and Demonstration Sections over Time, Including PC Data Collected Using VDOT's Profiler. PC = preconstruction.

Figure 6 shows the average MPD measurements for both chip seal reference and demo sections, captured at various post-construction intervals, as well as preconstruction, from SCRIM. Similarly, the average values along the length of each section were obtained from the left wheel path of SCRIM in the eastbound direction. Although the overall trends remain consistent—showing a decline in MPD over time and similar MPD values between the reference and demo sections—a noticeable shift occurs in the average MPD values compared to those values obtained from VDOT's profiler. Although this discrepancy could stem from differences in data processing techniques employed by the respective devices, the fundamental conclusion remains unchanged. Both chip seal reference and demo sections exhibit a similar performance trend over time, with variations possibly attributed to inherent measurement variability.

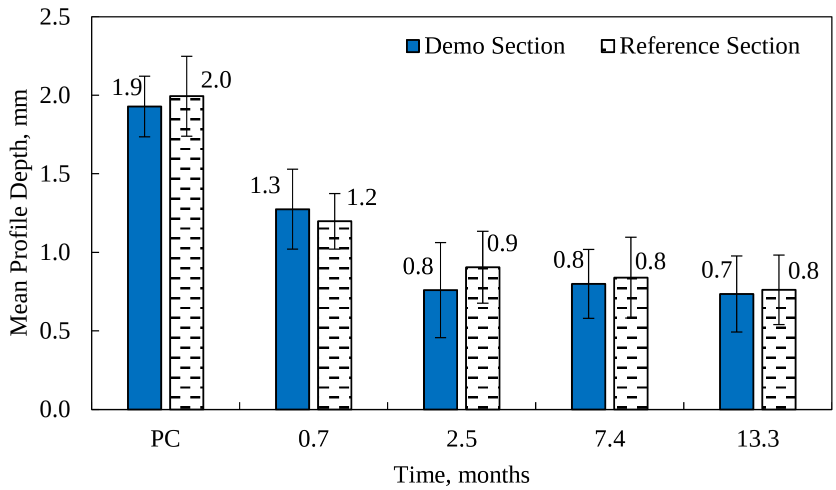

Figure 6. Average Mean Profile Depth Measurements for Chip Seal Reference and Demonstration Sections over Time, Including PC Data Collected Using SCRIM. PC = preconstruction; SCRIM = Sideway-Force Coefficient Routine Investigation Machine.

In a previous study (Boz, 2024), the evolution of macrotexture under traffic loads was documented from 8 different chip seal projects in Virginia, employing SCRIM to measure MPD. The MPD measurements for the chip seal reference and demo sections in the current study, also obtained via SCRIM, were combined with the data from the previous study to evaluate the relative performance of the sections.

Figure 7 shows the MPD values of the chip seal sections in this study compared with data from the prior investigation. The traffic (vehicle) volume corresponding to each macrotexture measurement was calculated by multiplying average daily traffic with the time of measurement (the number of days the treatments had been in place). As shown, the sections in the current study demonstrated a similar pattern to the trend observed previously but exhibited lower macrotexture levels, suggesting a potential underperformance.

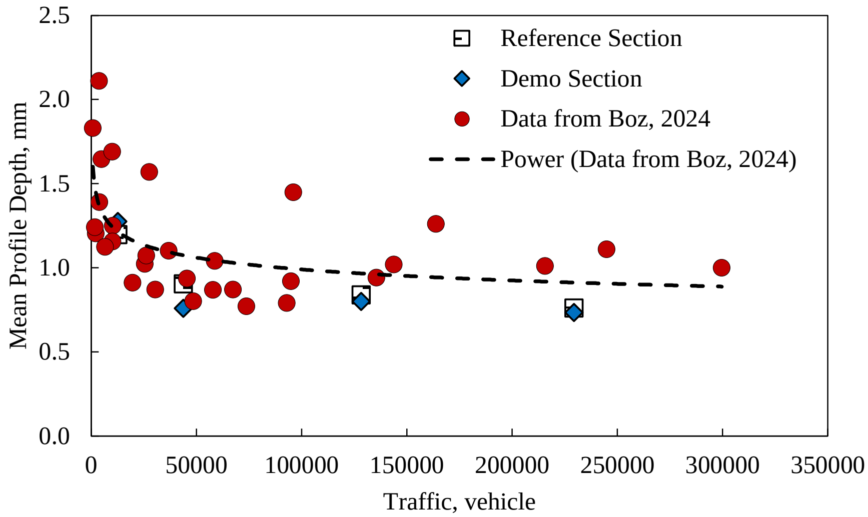

Figure 7. Comparison of Mean Profile Depth Measurements for Chip Seal Sections in the Current Study and Previous Investigation (Boz, 2024), Collected Using SCRIM. SCRIM = Sideway-Force Coefficient Routine Investigation Machine.

Friction measurements were conducted for the chip seal reference and demo sections at two intervals following construction, approximately 2.5 and 13 months post-construction. Friction levels were assessed using the Side-Way-Force Reading at 40 mph, obtained from SCRIM data in the eastbound direction. The initial dataset revealed statistically similar friction values between the two sections. The reference section exhibited a friction value of 66.6 (with a standard deviation of 13), and the demo section had a value of 64.6 (with a standard deviation of 14.1). Subsequent measurements taken approximately 13 months after construction indicated a decline in friction for both sections. The friction value for the reference section decreased to 61.2 (with a standard deviation of 8.4), and the demo section had a friction value of 59.7 (with a standard deviation of 13.5). Despite the decline, both sections continued to demonstrate statistically similar friction values, maintaining consistent trends throughout the observation periods.

Figure 8 presents the average rut depth measurements obtained from both chip seal reference and demo sections at various post-construction intervals, including preconstruction data. These measurements, collected using VDOT’s profiler, reflect average values across the length of each section in the eastbound direction. As previously noted, prior to construction, the reference section exhibited a rut depth of 0.15 inches, which was statistically similar to the demo section’s rut depth of 0.19 inches. Following construction, both sections experienced a minor decrease in rut depth at approximately 0.2 months post-construction, with the reference section measuring 0.12 inches and the demo section measuring 0.16 inches. Subsequent measurements indicated consistently lower rut depths for both sections, ranging from 0.10 to 0.12 inches. These findings suggest that the rut depth remained relatively stable throughout the observation period, suggesting comparable performance outcomes for the reference and demo sections.

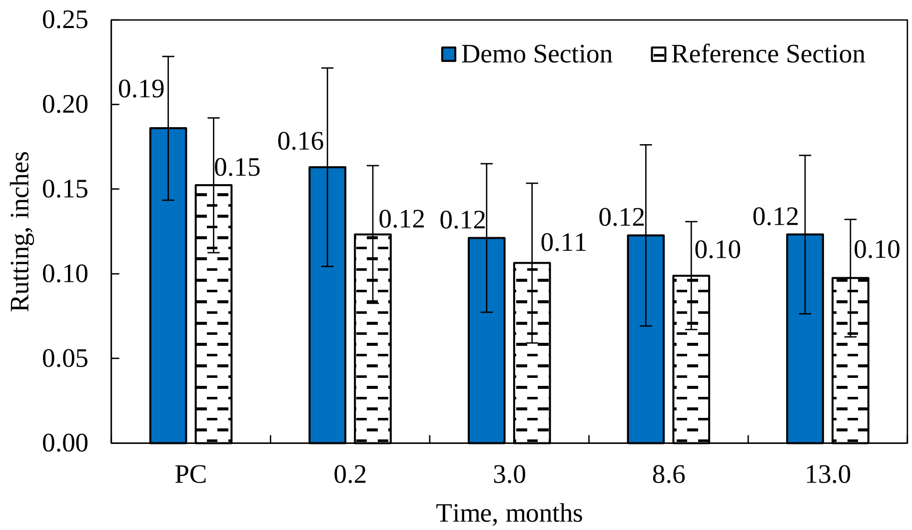

Figure 8. Average Rut Depth Measurements for Chip Seal Reference and Demonstration Sections over Time, Including PC Data. PC = preconstruction.

Figure 9 presents the average ride quality measurements, quantified in terms of IRI, obtained from both chip seal reference and demo sections during a 13-month period following construction, alongside the preconstruction data. These measurements, collected using VDOT’s profiler, reflect average values across the length of each section in the eastbound direction. As discussed previously, the demo section had a higher preconstruction IRI value compared with the reference section, indicating a rougher surface. Following construction, both sections showed slight improvements in smoothness, with the reference section exhibiting a relatively more substantial decrease in IRI, potentially due to the combination of relatively smoother preconstruction surface conditions and the use of the modified single-layer chip seal. During the subsequent months, the IRI values for both sections exhibited minor fluctuations attributable to inherent measurement variability.

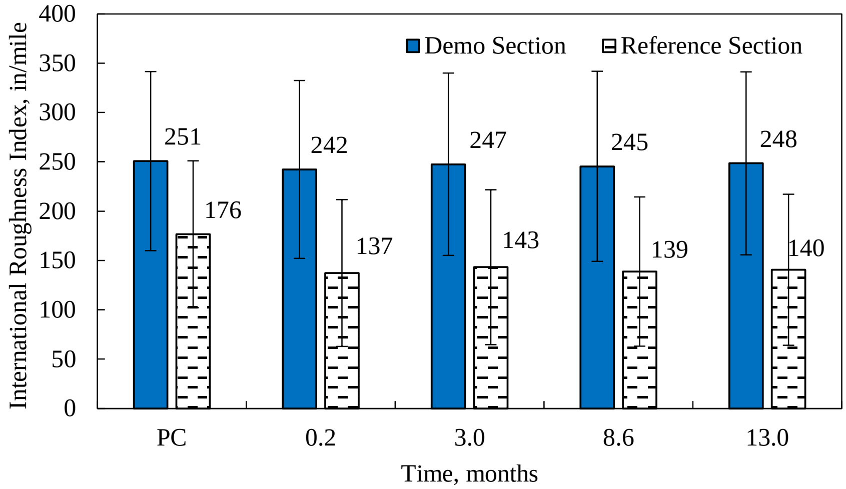

Figure 9. Average International Roughness Index Measurements for Chip Seal Reference and Demonstration Sections over Time, Including PC Data. PC = preconstruction.

The visual assessments conducted on both the reference and demo sections 20 months after their construction revealed that both sections had encountered issues with aggregate loss and/or bleeding. However, these problems were more severe in the demo section. This relatively better performance in the reference section can be expected because a modified single-layer chip seal application provides an additional mechanism to secure the first layer of aggregates, which in turn can prolong the service life of the chip seal compared with a traditional single-layer chip seal application (Boz, 2024).

Figure 10 illustrates instances of the reference section showing areas with bleeding and aggregate loss alongside areas performing well. These areas with bleeding and loss suggest application rates were either not optimal or not consistently applied across the longitudinal and transverse directions. The segments of the reference section that performed well demonstrate that, when chip seals are applied at optimal and consistent rates, the expected service life can be achieved.

(a) **(b)**

Figure 10. Reference Section 20 Months after Construction: (a) Areas with Aggregate Loss and Bleeding; (b) Well-Performing Segments

Figure 11 shows examples of aggregate loss and/or bleeding areas in the demo section, for segments exhibited non-uniform aggregate application rates (right lane heading into the page in the right picture) and treated with rectified aggregate application rates (right lane heading into the page in the left picture). A close examination of the right picture in Figure 11 reveals a relatively well-performing chip seal segment in the right lane (heading into the page) of the demo section, supporting the discussions provided in the preceding paragraph regarding achieving desired chip seal performance with proper application rates and techniques. It is worth noting that the issues encountered in both sections are common across the state (Boz, 2024). Appendix F includes example pictures taken from nearby routes during the visual survey for this project, demonstrating similar issues at that time.

(a) (b)

Figure 11. Demonstration Section Areas with Aggregate Loss and Bleeding 20 Months after Construction: (a) Segment with Non-Uniform Aggregate Application Rates; (b) Segment with Rectified Aggregate Application Rates

Microsurfacing

Comparison of Specifications

Microsurfacing application includes mixing emulsified asphalt, aggregate, mineral filler, water, and other additives in a specially designed paving machine. Table 5 compares requirements for VDOT’s current specification and the new specification developed for microsurfacing in this study. In general, test requirements for mix design are different between current and new specifications.

Table 5. Differences Between Current VDOT’s Current Specification and New Specification

Section	Current	New
Emulsified asphalt	• The emulsion shall be designated CQS-1h cationic quick-setting emulsion and shall conform to Cationic Type CSS-1h. • Ring and ball softening point of the residue, minimum = 140°F. • Pass towel test (VTM-89) in the 30 minutes at room temperature with job materials.	The emulsion shall be designated CQS-1hP cationic quick-setting emulsion and shall conform to AASHTO M 316 (AASHTO, 2021).

Section	Current	New
	• Residue, percent by evaporation, minimum 62%, as determined by VTM-78 (VDOT, 2017).	
Aggregate	Soundness loss shall not exceed 18%.	Soundness loss shall not exceed 18%, and the sand equivalency shall be no less than 65.
Mix Design	Job mix formula shall provide the following: 1. Compatibility of latex, aggregate, and emulsion, according to the Schulze-Breuer Test procedure. 2. A minimum Marshall Stability of 1,800 pounds when tested according to VTM-95 (VDOT, 2000). 3. A flow of between 6 and 16 units when tested according to VTM-95 (VDOT, 2000). 4. 4. An asphalt content that produces 4.7% voids in total mix for surface and 6.5% voids for rutfilling when tested according to VTM-95 (VDOT, 2000).	Job mix formula shall meet the requirements of AASHTO R 103, *Standard Practice for Micro-Surfacing Design* (AASHTO, 2021). Test methods include— • Mixing time at 77° F. • Wet Cohesion Test (30 minutes and 60 minutes). • Wet Stripping Test. • Wet Track Abrasion Loss Test (1-hour soak, 6-hour soak). • Lateral displacement. • Excess asphalt content by sand adhesion. • Saturated abrasion loss.

VTM = Virginia test method.

Table 6 shows aggregate gradation requirements for the current and new specifications. Type C and Type III aggregate gradations are recommended for high-traffic locations in VDOT’s current specification and the new specification developed in this study, respectively.

Table 6. Aggregate Grading Requirements

Sieve	Type C	Type III
	Current	New
	Percent Passing	
3/8	100	100
No. 4	70–95	70–90
No. 8	45–70	45–70
No. 16	32–54	28–50
No. 30	23–38	19–34
No. 50	16–29	12–25
No. 100	9–20	7–18

Evaluation of Preconstruction Surface Conditions

Visual Evaluation

A visual distress evaluation was conducted before treatments. Figures 12 and 13 show the existing pavement surface with different levels of cracking. Most of the cracks were longitudinal cracks (both on the wheel path and outside the wheel path), with some additional localized alligator cracks. Crack sealing (for cracks greater than ¼ inch) was performed on these sections.

Figure 12. Section Showing Crack Seal and Cracks on Wheel Path

Figure 13. Section with Cracks on Wheel Path

Automated Condition Assessment (VDOT's Pavement Management System)

Figure 14 shows Critical Condition Index (CCI) values for the northbound (NB) and southbound (SB) section of Route 132 before treatments. VDOT uses three condition indices to rate pavement distresses. The first index is the Load-Related Distress Rating, which measures pavement distresses caused by traffic loading. The second is the Non-Load-Related Distress Rating, which measures pavement distresses that are not load-related, such as distresses caused by environmental or climatic conditions. These two condition indices are rated on a scale of 0 to 100, where 100 signifies a pavement with no distresses. The third index is the CCI, which is the lower of the Load-Related Distress Rating and Non-Load-Related Distress Rating.

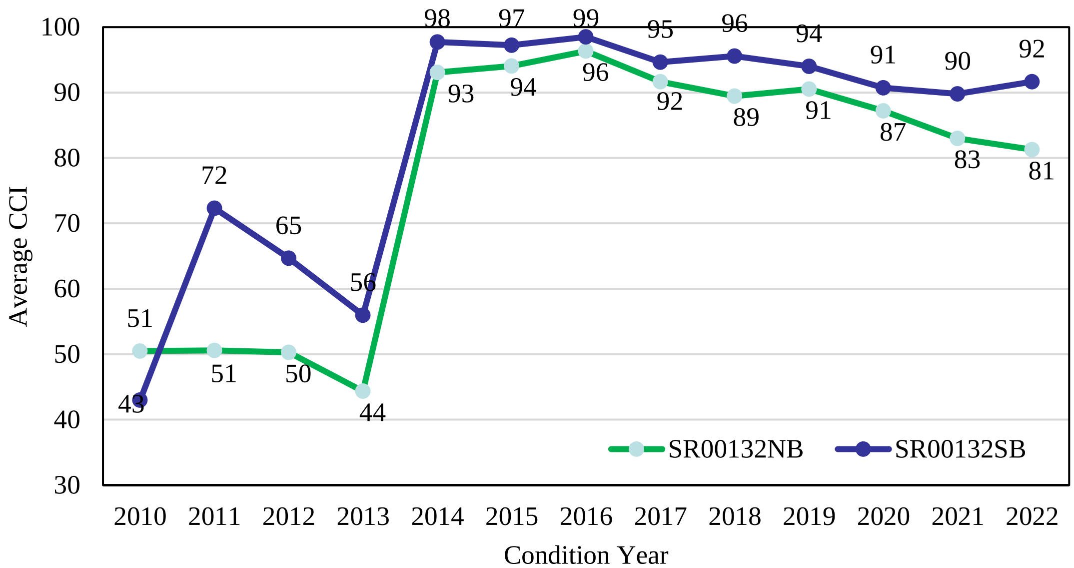

Figure 14. Route 132 Distress Data before Treatments. CCI = Critical Condition Index; SR = state route; NB = northbound; SB = southbound.

The most recent maintenance on Route 132 was done in 2013, a mill and fill using a SM 9.5 D mixture (1.5 inches thick). After the mill and fill, in 2014, CCI values for the NB and SB sections were 98 and 93, respectively, and, in 2022, CCI values for NB and SB sections were 92 and 81, respectively. The CCI values (in 2022) indicated that the SB and NB sections performed well for the past 9 years and were still in excellent (CCI value 90 and above) and good condition (CCI value between 70–89), respectively.

In general, for plant mix sections in the secondary routes, CCI values of 45 to 65 tend to trigger a recommendation of corrective maintenance (1.5-inches to 2-inches mill and fill); CCI values less than 45 would call for restorative maintenance. Sections with CCI values of 65 to 85 can be considered for preventive maintenance (Izeppi et al., 2015). Sections that are recommended for microsurfacing applications usually have CCI values higher than 60.

Quantitative Evaluation

Friction and MPD measurements were collected before microsurfacing application using SCRIM, and the results are shown in Table 7. The average friction values for Route 132's SB and NB lanes were statistically similar. Comparable average MPD values of 0.82 mm and 0.89 mm were observed for SB and NB lanes, respectively. Table 8 shows the rutting, MPD, and IRI values for both sections measured using VDOT's profiler van. Rutting and MPD values were statistically similar. The SB lane exhibited relatively rougher surface (higher IRI) than the NB lane.

Table 7. Friction and MPD Data before Treatment (Using SCRIM)

Route 132	SB (Reference Section)	NB (Demonstration Section)
SR40	64.0	61.6
Standard deviation	4.2	4.8
MPD	0.82	0.89
Standard deviation	0.08	0.21

MPD = mean profile depth; NB = northbound; SB = southbound; SCRIM = Sideway-Force Coefficient Routine Investigation Machine; SR40 = Sideway-Force Reading at 40 mph.

Table 8. Rutting, MPD, and IRI Data before Treatment (Using VDOT's Profiler Van)

Route 132	SB (Reference Section)	NB (Demonstration Section)
Rutting (inches)	0.08	0.08
Standard deviation	0.02	0.03
MPD (mm)	1.01	1.20
Standard deviation	0.17	0.36
IRI (inches/mile)	123	114
Standard deviation	75	61

IRI = international roughness index; MPD = Mean profile depth; NB = northbound; SB = southbound.

Documentation of Construction

Mix Design

Typical aggregate sources (Sources 1 and 2 as shown in Table 9) used in the Hampton Roads district for the microsurfacing applications were considered initially for both VDOT current and new specifications. After reviewing the gradation requirement for the new specification, it was found that neither of the current aggregate sources met the specification requirement for No. 4 and No. 200 sieves (Table 9). Another aggregate source (Source 3) was considered, and it met new specification gradation requirement. It was a coarser aggregate gradation than the other two sources. For the reference section, Source 2 aggregate was selected for VDOT current specification and Source 3 was selected for the demo section. Based on Table 9, Source 3 aggregate was approximately 13% coarser on the No. 4 sieve and 3% finer on the No. 200 sieve than Source 2 (Table 9). Further, the Source 3 materials met both VDOT's current and new specification gradation requirements.

Table 9. Gradation Comparison of Different Aggregate Sources

Sieve	Type III New Specification	Type C Current Specification	Source 1	Source 2	Source 3
	Percent Passing				
3/8	100	100	100	100	100
No. 4	70–90	70–95	94.0	92.4	81.7

Sieve	Type III	Type C	Source 1	Source 2	Source 3
	New Specification	Current Specification			
	Percent Passing				
No. 8	45–70	45–70	66.3	62.2	53.6
No. 16	28–50	32–54	43.2	39.5	37.2
No. 30	19–34	23–38	28.0	25.6	28.6
No. 50	12–25	16–29	17.9	17.0	23.1
No. 100	7–18	9–20	11.2	10.8	16.8
No. 200	8–15	5–12	6.8	6.6	9.5

Appendix G details the final mix design for both reference and demo sections. Both mixes used 99% screening and 1% cement. Emulsion content (7.5%) was also the same, even though the specifications required different test methods. The CQS-1H LM emulsion type was used for both sections.

Construction

The reference and demo microsurfacing sections were placed from mile points 0 to 1.26 on Route 132 SB on October 6, 2022 and on Route 132 NB on October 7, 2022 (Route 132 is an undivided, two-lane highway). Microsurfacing was applied over the entire pavement test section, and fog seal was applied only over the shoulders. Before the microsurfacing application, the road surface was cleaned properly, and then tack coat was applied over the pavement surface. The ambient temperature when placement commenced was 75°F, and the corresponding pavement temperature was 85°F. Figure 15 shows the tack coat application (spray bars with nozzles to spray the emulsion), and Figure 16 shows the equipment used to apply the microsurfacing mixture. Microsurfacing equipment included a rubber strike-type continuous mixing unit and a spreader box with augers. Figure 17 shows a finished microsurfacing surface before curing, and Figure 18 shows the final surfaces for the reference and demo sections. Fog seal was applied on both sides of the shoulders in accordance with the new provision specification, as shown in Figure 19.

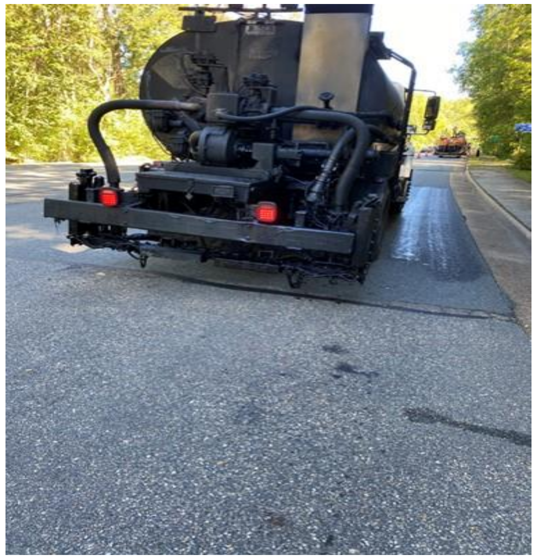

Figure 15. Tack Coat Application in the Demonstration Section

Figure 16. Placement of the Microsurfacing Demonstration Section

Figure 17. Microsurfacing Demonstration Section before Curing

Figure 18. Microsurfacing Reference (Left) and Demonstration (Right) Sections

Figure 19. Fog Sealing on Shoulder

Hampton Roads district staff collected a quality assurance sample using a plastic container for microsurfacing mix and determined the residual asphalt content. Both mixes met the residual asphalt content specifications. The residual asphalt content was 7.81% (specification range 6–9%) for the reference section mix and 7.03% (specification range 6.5–8.5%) for the demo section mix. However, the demo section mix showed lower-than-design emulsion content (7.5%).

Field Performance

Rut depth, MPD, and IRI data were collected using VDOT's profiler before and after microsurfacing applications (Table 10). Rut depths were statistically similar before and after the treatments. The MPD values for the reference section did not show a clear trend after microsurfacing, and the demo section showed a slight decrease in values after microsurfacing. The IRI values did not change for either section after treatment.

Table 10. Rutting, MPD, and IRI Data (Using VDOT's Profiler Van)

Route 132	August 2022 (before Treatment)		December 2022		May 2023	
	SB (Reference)	NB (Demo)	SB (Reference)	NB (Demo)	SB (Reference)	NB (Demo)
Rut Depth (inches)	0.08	0.08	0.092	0.096	0.086	0.088
SD	0.02	0.03	0.02	0.03	0.025	0.04
MPD (mm)	1.01	1.20	1.31	1.18	1.23	0.91
SD	0.17	0.36	0.36	0.35	0.30	0.23
IRI (inches/mile)	123	114	127	114	123	115
SD	75	61	72	60	72	53

Demo = demonstration. IRI = International roughness index; MPD = mean profile depth; NB = northbound; SB = southbound; SD = standard deviation.

The friction and MPD measurements were also collected using SCRIM (Table 11). On October 20, 2022, only one measurement was taken—for the demo section. On November 15, 2022 and May 5, 2023, tests were conducted on both directions for both sections. The friction numbers were elevated from September to November because friction generally increases when temperature drops. Table 11 includes the average air and pavement temperature information collected during the tests. Currently, a method to get a standardized friction number based on temperature correction factors is not available (Boz et al., 2023). SCRIM data for friction and MPD after microsurfacing applications did not show a clear trend between the reference and demo sections.

Table 11. Friction and MPD Data (Using SCRIM)

Route 132	September 2022 (before Treatment)		October 2022 (after Treatment)		November 2022 (after Treatment)		May 2023 (after Treatment)	
	SB (Reference)	NB (Demo)	SB (Reference)	NB (Demo)	SB (Reference)	NB (Demo)	SB (Reference)	NB (Demo)
SR40	64.1	61.5	—	68.6	83.1	66.0	58.1	69.6
SD	4.5	5.1	—	2.8	3.7	4.1	6.1	5.6
MPD (mm)	0.82	0.90	—	0.83	1.13	0.85	0.78	0.96
SD (mm)	0.08	0.22	—	0.20	0.13	0.19	0.15	0.16
Air Temperature	70°F		48°F		48°F		71°F	
Pavement Temperature	75°F		50°F		50°F		95°F	

— = No testing was performed. Demo = demonstration. MPD = mean profile depth; NB = northbound; SB = southbound; SCRIM = Sideway-Force Coefficient Routine Investigation Machine; SR40 = Side-Way-Force Reading at 40 mph; SD = standard deviation.

CONCLUSIONS

- *The new chip seal specification developed in this study did not show improved performance outcomes for the chip seal (demo) section compared with the outcomes observed in the chip seal (reference) section constructed using VDOT's current chip seal specification.*

- *The field performance of the chip seal treatment constructed under the new specification was affected by several factors*. Several construction quality issues were encountered during the placement of the demo section, including challenges in achieving the target aggregate application rate and non-uniform spreading of aggregates. In addition, the distinct structural differences between the reference and demo sections, with one being a modified single-layer chip seal application and the other a single-layer chip seal application, contributed to the observed distinctions in performance. Further assessment of the new specification through additional field trials is necessary to comprehensively evaluate its effectiveness.

- *The new microsurfacing specification developed in this study did not yield any short-term performance differences for the microsurfacing (demo) section compared with the outcomes observed in the microsurfacing (reference) section constructed using VDOT's current microsurfacing specification.* However, further performance evaluation is warranted to confirm the findings of this study. Notably, the new specification has different aggregate gradation requirements than VDOT's current specification. For certain districts, meeting such a requirement may not be cost-effective, considering the haul distances of different aggregate sources.

RECOMMENDATIONS

1. *VDOT's Materials Division and Virginia Transportation Research Council (VTRC) should plan and execute more modified single-layer chip seal field trials designed in accordance with the new specification developed in this study.*

2. *VDOT's Materials Division should continue to use VDOT's current special provision for microsurfacing projects.*

IMPLEMENTATION AND BENEFITS

The researchers and the technical review panel (listed in the Acknowledgments) for the project collaborate to craft a plan to implement the study recommendations and to determine the benefits of doing so. This process is to ensure that the implementation plan is developed and approved with the participation and support of those involved with VDOT operations. The implementation plan and the accompanying benefits are provided here.

Implementation

With regard to Recommendation 1, VTRC with the help of VDOT districts, will identify opportunities for field trials during the 2025 construction season to collect additional data for further evaluation of the new chip seal specification.

Due to the construction challenges encountered during the initial demonstration project, another demonstration project utilizing a single-layer chip seal application was conducted on September 15, 2023, at the request of the contractor. This project was carried out on Cedar Lane along Route 666 in the Richmond district, covering mile points between 0 and 0.9. The location, a cul-de-sac street, experiences low traffic volumes and is also frequented by farming vehicles. Notably, this demonstration section was not paired with a control or reference section. Anecdotal accounts indicate that the project was successful. Furthermore, relatively improved construction practices were noted: In the initial 500-ft trial section, the emulsion content application rates were lower than intended, and the aggregate application rate was higher. These rates were subsequently adjusted to meet the target emulsion and aggregate application rates (0.34 gal/yd^2 and 17.4 lb/yd^2, respectively) for the remainder of the section. Appendix H features photographs of this demonstration section. However, at the time of this writing, performance data to assess the outcome of this project were not yet available.

With regard to Recommendation 2, VDOT's Materials Division agrees to continue to use the current microsurfacing specification.

Benefits

Chip seals and microsurfacing are preservation treatments that are frequently used in Virginia to extend the service life of pavements. VDOT allocates substantial investments to these projects. For instance, more than 35 million dollars were allocated for chip seal and microsurfacing projects in 2021. Achieving innovative and improved practices that enhance the service life of these treatments by even 1 year can lead to substantial cost savings for VDOT.

Recommendation 1 focuses on efforts to achieve improved practices for chip seals.

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APPENDIX A: VDOT'S CURRENT SPECIFICATION FOR CHIP SEALS

SP314-000100-00

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
ASPHALT SURFACE TREATMENT

September 13, 2012; Reissued July 12, 2016

I. DESCRIPTION

This work shall consist of the application of a single or multiple course of asphalt surface treatment according to the Specifications and as specified herein.

II. DEFINITION OF TERMS

Seal Treatment is defined as one application of asphalt material and one application of cover aggregate.

Modified Single Seal is defined as two applications of asphalt material, one application of cover aggregate and one application of blot fine aggregate.

Modified Double Seal is defined as three applications of asphalt material, two applications of cover aggregate and one application of blot fine aggregate.

III. MATERIALS

The Contractor shall demonstrate the compatibility of the asphalt emulsion and cover aggregate (excluding the blot seal) prior to construction of the surface treatment. This testing shall be conducted according to VTM-65 in the presence of the Engineer for each asphalt and aggregate combination. In addition, the Contractor shall conduct the compatibility test at least once a week on stockpiled materials and any additional test, as deemed necessary by the Engineer. Compatibility test results shall be submitted to the Engineer. All material combinations shall pass the compatibility test unless waived in writing by the Engineer.

If during the life of this project excessive loss of cover aggregate occurs, the Engineer may suspend the work according to Section 108 of the Specifications until the cause of the loss of cover material is corrected.

(a) **Asphalt Materials** shall conform to Section 210 of the Specifications except as specified herein.

CRS-2 shall be a rapid setting cationic emulsified asphalt when tested according to ASHTO T59 *Testing Emulsified Asphalt*. CRS-2 shall meet the requirements of Type II coating ability.

CRS-2h shall conform to CRS-2 except that the penetration shall be 40 to 100.

RC-250 when permitted during the period of May 1 to October 1 shall meet the requirements of Type I coating ability. When permitted during the period of October 1 to May 1 Type II coating ability shall apply.

CRS-2M (Polymer Modified Cationic Emulsified Asphalt) shall meet the physical requirements of asphalt material per AASHTO M316 for CRS-2L or CRS-2P except as modified herein. The minimum elastic recovery for CRS-2L, as tested according to AASHTO T301, shall be 50 percent.

The Contractor shall provide written certification of the test results.

(b) **Cover Material** — Coarse and Fine aggregate shall conform to Section 203 and 202 of the Specifications. Coarse aggregate shall be a minimum Grade B. Lightweight aggregate shall conform to Section 206 of the Specifications except as noted herein. For light weight aggregate when the material passing the No. 200 sieve by washing is dust of fracture, the percentage of deleterious material shall not exceed 1.7 percent. Crushed stone shall only be used on roads of Traffic Groups VI and above unless the surface treatment consists of modified single seal treatment or modified double seal treatment. Aggregates shall not be used within 24 hours of washing. Aggregate from more than one source shall not be furnished for a specified route or a group of sub-division routes unless permitted by the Engineer.

The following modifies the aggregate material as defined in Section 203 of the Specifications:

Designation	Modification
N	Nonpolishing material only
L	Lightweight
G	Washed gravel only

Notes: Where 8N is specified, it shall meet the gradation requirements of No. 8P.

Where 8L is specified it shall meet the following gradation:

Sieve Size	Percent Passing
1/2	100
3/8	75–100
No. 4	10–40
No. 8	max. 5

Where 8G is specified, it shall meet the gradation requirements of No. 8P.

IV. PROCEDURES

Weather limitations for asphalt surface treatment work shall be according to Section 314 of the Specifications. The Contractor shall have a certified Surface Treatment Technician present during the surface treatment operation.

The Contractor shall use one steel wheel roller and one pneumatic-tire roller on modified single seal, modified double seal and seal treatments using CRS-2L asphalt material in a sequence approved by the Engineer. The Contractor is directed to the exceptions to these requirements found in IV.(c) of this special provision. These treatments shall be subjected to a minimum of one complete pass of each type of roller on either the cover aggregate or the blot seal coat.

(a) **Seal Treatment** shall conform to Section 312 of the Specifications. When seal treatment is specified, the Contractor shall protect the cover aggregate from traffic until the asphalt material has sufficiently cured to carry traffic without damage to the treatment.

The rate of application shall be according to VTM-66. The rate of application for the cover aggregate and asphalt emulsion shown in the contract are approximate and the actual rate shall be determined by the Contractor and approved by the Engineer.

After the roadway has been treated and cured, the Contractor shall lightly broom the surface to remove any excessive aggregate according to Section 312.04 of the Specifications and as directed by the Engineer. Brooming shall be performed in such a manner as not to damage the embedded aggregate material.

(b) **Modified Single Seal and Modified Double Seal Treatments**, when specified, shall be lightly broomed on the surface by the Contractor to remove any excessive aggregate according to Section 312.04 of the Specifications and as directed by the Engineer. Brooming shall be performed in such manner as not to damage the embedded aggregate material.

No traffic, including delivery trucks, shall be allowed on modified seal treatments until after the blot coat material has been placed and rolled.

1. **Modified Single Seal Treatment**

a. Approximately 0.17 gallons per square yard of asphalt material, of the type specified, shall be applied to the existing surface immediately followed by an application of approximately 15 pounds per square yard of aggregate size No. 8P. The aggregate shall be spread uniformly (one aggregate deep) over the treated surface.

The aggregate shall be rolled immediately at least once with a self-propelled roller of an approved design. When a continuous uninterrupted modified single seal treatment train method is employed, rolling of the initial aggregate course may be omitted.

b. Immediately after the seal coat has been rolled according to IV.(b)1.a., herein a blot seal coat consisting of approximately 0.15 gallons per square yard of asphalt material, of the type specified, shall be applied to the surface treated pavement followed by a uniform application of approximately 10 pounds per square yard of fine aggregate. The fine aggregate shall be Grading A, B or F natural or manufactured according to Section 202 or No. 9 aggregate according to Section 203 of the Specifications, except that the material shall have no more than 5 percent passing the No. 200 sieve by washed analysis. The Contractor is directed to the exceptions to these requirements found in IV.(c) of this special provision. An increase in the application rate for blotter material may be necessary when using natural sand and if the desired results are not achieved with this material, the Engineer may require the use of manufactured sand. Fine aggregate from more then one source shall not be used intermittently. The fine aggregate shall be applied by the use of a self-propelled aggregate spreader of approved design. The blot coat shall be rolled immediately at least once with a self-propelled roller of an approved design. At least 48 hours after the blot coat application, the roadway surface shall be lightly broomed as directed by the Engineer.

2. **Modified Double Seal Treatment**

a. Two applications of asphalt material and cover aggregate shall be applied according to Section IV.(b)1.a. herein, except that at least one complete pass shall be made with the roller after each aggregate application.

b. A blot coat shall be applied according to IV.(b)1.b. herein.

The application temperature for liquid asphalt material shall conform to Table III-1 of Section 310 of the Specifications, except that the minimum application temperature for CRS-2 and CRS-2L shall be 160 degrees F.

(c) **District-Specific Exceptions for Modified Single Seal and Modified Double Seal Treatments and Seal Treatment**

Bristol District — The blot coat for use in modified single seal and modified double seal shall be No. 9 aggregate conforming to Section 203 of the Specifications and applied at a rate of 12 pounds per square yard in lieu of sand. Two pneumatic-tire rollers shall be used on modified single seal, modified double seal and seal treatments using CRS-2L asphalt material.

Lynchburg, Salem, and Staunton Districts — The blot coat for use in modified single seal and modified double seal shall be No. 9 aggregate conforming to Section 203 of the Specifications and applied at a rate of 12 pounds per square yard in lieu of sand.

Hampton Roads District — The blot coat for use in modified single seal and modified double seal shall be manufactured sand only conforming to Section 202 of the Specifications.

Fredericksburg District (only Caroline, Spotsylvania, and Stafford Counties) — The blot coat for use in modified single seal and modified double seal shall be manufactured stone sand conforming to Section 202 of the Specifications.

(d) **Prime Coat**, when specified, shall be applied according to Section 311 of the Specifications. When cover material is specified, rolling shall be performed according to Section 312 of the Specifications.

The prime coat shall be permitted to cure prior to the next application of asphalt.

During the period between application of the prime coat and the seal coat, the primed surface shall be kept in repair. Holes, ravels, and areas deficient in primer shall be patched and repaired with asphalt-treated materials by penetration methods or other approved procedures.

(e) **Maintenance, Protection and Performance of the Work** — The Contractor shall be responsible for the maintenance and protection of the seal treatment on the roadway for a period of 48 hours after application.

The Contractor shall exercise control of the delivery and application of the surface treatment materials to prevent damage to the roadway surface. The speed of the delivery equipment and pilot truck shall be limited to a maximum 15 miles per hour. The maintenance and protection shall include, but not be limited to, the placement of signs; the use of flaggers and pilot trucks; and placement of additional asphalt and aggregate material. In the event a failure occurs prior to acceptance, the Contractor shall repair or replace the failed treatment as directed by the Engineer, at no additional cost to the Department.

V. EQUIPMENT

(a) Asphalt Distributors and Aggregate Spreaders

1. Distributors and spreaders shall be calibrated by the Contractor in the presence of the Engineer prior to placing surface treatment; to ensure an even and accurate spray, and aggregate distribution.

2. Asphalt distributors shall be equipped with proper spray nozzles including end nozzles for the application rate specified, to provide uniform coverage throughout the width of the application.

(b) Rollers

1. One steel wheel roller and one pneumatic-tire roller shall be used on modified single seal, modified double seal and seal treatment using CRS-2L asphalt material. The Contractor is directed to the exceptions to these requirements found in IV.(c) of this special provision. The steel wheel roller weight shall be between 6 and 8 tons for the tandem type and between 8 and 10 tons for the three-wheel type.

2. Two pneumatic-tire rollers shall be used on the conventional type seal treatment.

VI. MEASUREMENT AND PAYMENT

Liquid asphalt material for seal treatment will be measured and paid for according to Section 312 of the Specifications.

Aggregate for seal treatment will be measured and paid for in square yards on a plan quantity basis, which price bid shall include furnishing and applying aggregate, protection of the asphalt surface treatment and all incidentals necessary to complete the work. Authorized increases or decreases to the plan quantity will be adjusted according to Section 109 of the Specifications.

Modified single seal and **modified double seal** treatments will be measured and paid for in square yard on a plan quantity basis, which price bid shall include all cost for furnishing and applying liquid asphalt material and cover aggregate, protection of the asphalt surface treatment and all incidentals necessary to complete the work. Authorized increases and decreases to the plan quantities will be adjusted according to Section 109 of the Specifications.

Brooming shall be included in the price bid for other appropriate items.

Payment will be made under:

Pay Item	Pay Unit
Aggregate (type)	Square Yard
Modified Single Seal	Square Yard
Modified Double Seal	Square Yard

APPENDIX B: NEW SPECIFICATION DEVELOPED IN THIS STUDY FOR CHIP SEALS

SQ314-000100-001

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
ASPHALT SURFACE TREATMENT for NCHRP DEMO PROJECT

August 20, 2021

I. DESCRIPTION

This work shall consist of the application of a single or multiple course of asphalt surface treatment according to the Specifications and as specified herein.

II. DEFINITION OF TERMS

Seal Treatment is defined as one application of asphalt material and one application of cover aggregate.

Modified Single Seal is defined as two applications of asphalt material, one application of cover aggregate and one application of blot fine aggregate.

Modified Double Seal is defined as three applications of asphalt material, two applications of cover aggregate and one application of blot fine aggregate.

III. MATERIALS

The Contractor shall demonstrate the compatibility of the asphalt emulsion and cover aggregate (excluding the blot seal) prior to construction of the surface treatment. This testing shall be conducted according to VTM-65 in the presence of the Engineer for each asphalt and aggregate combination. In addition, the Contractor shall conduct the compatibility test at least once a week on stockpiled materials and any additional test, as deemed necessary by the Engineer. Compatibility test results shall be submitted to the Engineer. All material combinations shall pass the compatibility test unless waived in writing by the Engineer.

If during the life of this project excessive loss of cover aggregate occurs, the Engineer may suspend the work according to Section 108 of the Specifications until the cause of the loss of cover material is corrected.

(a) **Asphalt Materials** shall conform to Section 210 of the Specifications except as specified herein.

CRS-2 shall be a rapid setting cationic emulsified asphalt when tested according to AASHTO T59 *Testing Emulsified Asphalt*. CRS-2 shall meet the requirements of Type II coating ability.

CRS-2h shall conform to CRS-2 except that the penetration shall be 40 to 100.

RC-250 when permitted during the period of May 1 to October 1 shall meet the requirements of Type I coating ability. When permitted during the period of October 1 to May 1 Type II coating ability shall apply.

CRS-2M (Polymer Modified Cationic Emulsified Asphalt) shall meet the physical requirements of asphalt material per AASHTO M316 for CRS-2L or CRS-2P except as modified herein. The minimum elastic recovery for CRS-2L, as tested according to AASHTO T301, shall be 50 percent.

The Contractor shall provide written certification of the test results.

(b) **Cover Material** — Coarse and Fine aggregate shall conform to Section 203 and 202 of the Specifications. Fracture and abrasion requirements for coarse aggregate shall conform to Table 2 of AASHTO MP 27 (M 340). Lightweight aggregate shall conform to Section 206 of the Specifications except as noted herein. For light weight aggregate when the material passing the No. 200 sieve by washing is dust of fracture, the percentage of deleterious material shall not exceed 1.7 percent. Crushed stone shall only be used on roads of Traffic Groups VI and above unless the surface treatment consists of modified single seal treatment or modified double seal treatment. Aggregates shall not be used within 24 hours of washing. Aggregate from more than one source shall not be furnished for a specified route or a group of sub-division routes unless permitted by the Engineer.

The following modifies the aggregate material as defined in Section 203 of the Specifications:

Designation	Modification
N	Nonpolishing material only
L	Lightweight
G	Washed gravel only

Notes: Where N or G is specified, it shall meet one of the gradation requirements as specified in Table 1 of AASHTO MP 27.

Where L is specified it shall meet the following gradation:

Sieve Size	Percent Passing
1/2	100
3/8	75-100
No. 4	10-40
No. 8	max. 5

IV. PROCEDURES

Weather limitations for asphalt surface treatment work shall be according to Section 314 of the Specifications. In addition, the Contractor shall not place the surface treatment when the surface temperature is exceed 140 degree F. The Contractor shall have a certified Surface Treatment Technician present during the surface treatment operation.

The Contractor shall provide proof of calibration of the asphalt distributor and the aggregates spreader. Calibration shall be conducted no earlier than 10 days prior to the surface treatment operations. Uniformity of the aggregate applied transverse to the pavement centerline shall be in accordance with ASTM D5624. Tolerance for each pad tested for transverse spread rate shall be within 10 percent of the average of the total transverse rate.

Thermoplastic pavement markings shall be removed prior to the surface treatment application.

The Contractor shall use pneumatic-tire rollers. The Contractor is directed to the exceptions to these requirements found in IV.(c) of this special provision. These treatments shall be subjected to a minimum of three complete roller passes on the cover aggregates. One pass is defined as the roller moving over the aggregates for the entire width of the pavement lane in a single direction. Ensure the rolling is completed quickly enough to embed the aggregates, before the emulsified asphalt breaks and no longer than 15 min after the emulsified asphalt is sprayed. If necessary, final rolling may be accomplished using the steel wheel roller in one pass.

(a) **Seal Treatment** shall conform to Section 312 of the Specifications. When seal treatment is specified, the Contractor shall protect the cover aggregate from traffic until the asphalt material has sufficiently cured to carry traffic without damage to the treatment.

The rate of application shall be according to AASHTO PP 82 (R 102). The rate of application for the cover aggregate and asphalt emulsion shown in the contract are approximate and the actual rate shall be determined by the Contractor and approved by the Engineer.

After the roadway has been treated and cured, the Contractor shall lightly broom the surface to remove any excessive aggregate according to Section 312.04 of the Specifications and as directed by the Engineer. Brooming shall be performed in such a manner as not to damage the embedded aggregate material.

(b) **Modified Single Seal and Modified Double Seal Treatments**, when specified, shall be lightly broomed on the surface by the Contractor to remove any excessive aggregate according to Section 312.04 of the Specifications and as directed by the Engineer. Brooming shall be performed in such manner as not to damage the embedded aggregate material.

No traffic, including delivery trucks, shall be allowed on modified seal treatments until after the blot coat material has been placed and rolled.

1. **Modified Single Seal Treatment**

a. The initial layer of specified asphalt material with the rate of application as determined from AASHTO PP 82 (R 102), shall be applied to the existing surface immediately followed by an application, at a rate as determined from AASHTO PP 82 (R 102), of aggregate size as determined from AASHTO MP 27 (M 340). The aggregate shall be spread uniformly (one aggregate deep) over the treated surface.

The aggregate shall be rolled immediately following the requirements found in IV of this special provision.

b. Immediately after the seal coat has been rolled according to IV.(b)1.a., herein a blot seal coat consisting of approximately 0.15 gallons per square yard of asphalt material, of the type specified, shall be applied to the surface treated pavement followed by a uniform application of approximately 10 pounds per square yard of fine aggregate. The fine aggregate shall be Grading A, B or F natural or manufactured according to Section 202 or No. 9 aggregate according to Section 203 of the Specifications, except that the material shall have no more than 5 percent passing the No. 200 sieve by washed analysis. The Contractor is directed to the exceptions to these requirements found in IV.(c) of this special provision. An increase in the application rate for blotter material may be necessary when using natural sand and if the desired results are not achieved with this material, the Engineer may require the use of manufactured sand. Fine aggregate from more than one source shall not be used intermittently. The fine aggregate shall be applied by the use of a self-propelled aggregate spreader of approved design. The blot coat shall be rolled immediately at least once with a self-propelled roller of an approved design. If necessary, final rolling may be accomplished using the steel wheel roller in one pass. At least 48 hours after the blot coat application, the roadway surface shall be lightly broomed as directed by the Engineer.

2. **Modified Double Seal Treatment**

a. Two applications of asphalt material and cover aggregate shall be applied according to Section IV.(b)1.a. herein, except that at least one complete pass shall be made with the roller after each aggregate application.

b. A blot coat shall be applied according to Section IV.(b)1.b. herein. The application temperature for liquid asphalt material shall conform to Table III-1 of Section 310 of the Specifications, except that the minimum application temperature for CRS-2 and CRS-2L shall be 160 degrees F.

(c) **District-Specific Exceptions for Modified Single Seal and Modified Double Seal Treatments and Seal Treatment**

Bristol District — The blot coat for use in modified single seal and modified double seal shall be No. 9 aggregate conforming to Section 203 of the Specifications and applied at a rate of 12 pounds per square yard in lieu of sand. Two pneumatic-tire rollers shall be used on modified single seal, modified double seal and seal treatments using CRS-2L asphalt material.

Lynchburg, Salem, and Staunton Districts — The blot coat for use in modified single seal and modified double seal shall be No. 9 aggregate conforming to Section 203 of the Specifications and applied at a rate of 12 pounds per square yard in lieu of sand.

Hampton Roads District — The blot coat for use in modified single seal and modified double seal shall be manufactured sand only conforming to Section 202 of the Specifications.

Fredericksburg District (only Caroline, Spotsylvania, and Stafford Counties)—The blot coat for use in modified single seal and modified double seal shall be manufactured stone sand conforming to Section 202 of the Specifications.

(d) **Prime Coat**, when specified, shall be applied according to Section 311 of the Specifications. When cover material is specified, rolling shall be performed according to Section 312 of the Specifications. The prime coat shall be permitted to cure prior to the next application of asphalt.

During the period between application of the prime coat and the seal coat, the primed surface shall be kept in repair. Holes, ravels, and areas deficient in primer shall be patched and repaired with asphalt-treated materials by penetration methods or other approved procedures.

(e) **Maintenance, Protection and Performance of the Work** — The Contractor shall be responsible for the maintenance and protection of the seal treatment on the roadway for a period of 48 hours after application. The Contractor shall swept off the excessvie and loose aggregates on the final surface.
The Contractor shall exercise control of the delivery and application of the surface treatment materials to prevent damage to the roadway surface. The speed of the delivery equipment and pilot truck shall be limited to a maximum 15 miles per hour. The maintenance and protection shall include, but not be limited to, the placement of signs;

the use of flaggers and pilot trucks; and placement of additional asphalt and aggregate material. In the event a failure occurs prior to acceptance, the Contractor shall repair or replace the failed treatment as directed by the Engineer, at no additional cost to the Department.

V. EQUIPMENT

(a) Asphalt Distributors and Aggregate Spreaders

1. Distributors and spreaders shall be calibrated by the Contractor in the presence of the Engineer prior to placing surface treatment according to Section IV herein; to ensure an even and accurate spray, and aggregate distribution. The Contractor shall submit the proof of the calibration to the Engineer.
2. Asphalt distributors shall be equipped with proper spray nozzles including end nozzles for the application rate specified, to provide uniform coverage throughout the width of the application. The spray bar nozzles shall produce a uniform double or triple lap application fan spray, and the shutoff shall be instantaneous, with no dripping. All nozzles shall be oriented at the same angle between 15 and 30 degree.

(b) Rollers

1. The pneumatic-tire roller shall be varied from 6 to 8 tons to achieve a minimum contact pressure of 80 psi (pounds per square inch). The Contractor is directed to the exceptions to these requirements found in IV.(c) of this special provision. The steel wheel roller weight shall be limited to 5 tons and vibration shall not be used.
2. A minimum two pneumatic-tire rollers shall be used on the surface treatment.

VI. MEASUREMENT AND PAYMENT

Liquid asphalt material for seal treatment will be measured and paid for according to Section 312 of the Specifications.

Aggregate for seal treatment will be measured and paid for in square yards on a plan quantity basis. This price shall include furnishing and applying aggregate, protection of the asphalt surface treatment and all incidentals necessary to complete the work. Authorized increases or decreases to the plan quantity will be adjusted according to Section 109 of the Specifications.

Modified single seal and **modified double seal** treatments will be measured and paid for in square yard on a plan quantity basis. This price shall include all cost for furnishing and applying liquid asphalt material and cover aggregate, protection of the asphalt surface treatment and all incidentals necessary to complete the work. Authorized increases and decreases to the plan quantities will be adjusted according to Section 109 of the Specifications.

Brooming shall be included in the price bid for other appropriate items.

Payment will be made under:

Pay Item	Pay Unit
Aggregate (type)	Square Yard
NS Modified Single Seal	Square Yard
NS Modified Double Seal	Square Yard

APPENDIX C: VDOT'S CURRENT SPECIFICATION FOR MICROSURFACING

SP312-000110-00

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
LATEX MODIFIED EMULSION TREATMENT (MICRO-SURFACING)

August 10, 2010; Reissued July 12, 2016

I. DESCRIPTION

This work shall include furnishing and placing a latex modified emulsion to existing roadway surfaces as specified herein and as directed by the Engineer.

II. MATERIALS

A. **Emulsified asphalt** shall be a quick set latex modified cationic emulsion conforming to Section 210 of the Specifications and the following:

1. The emulsion shall be designated CQS-1h cationic quick setting emulsion and shall conform to Cationic Type CSS-1h.
2. Ring and ball softening point of the residue, minimum = 140 degrees F.
3. Pass towel test (VTM-89) in the 30 minutes at room temperature with job materials.
4. Residue, percent by evaporation, minimum 62 percent as determined by VTM-78.
5. Material shall be furnished according to the Departments Asphalt Acceptance Program.

B. **Aggregate** shall be non-polishing crushed stone conforming to Section 202 of the Specifications, except the soundness loss shall not exceed 18 percent.

Gradation of the aggregate shall be according to the following:

SCREEN SIZE	TYPE A (% Passing)	TYPE B (% Passing)	TYPE C (% Passing)	RUTFILLING (% Passing)
No.3/8	100	100	100	100
No.4	100	90-100	70-95	70-95
No.8	65-90	65-90	45-70	45-70
No.16	45-70	45-70	32-54	32-54
No.30	30-50	30-50	23-38	23-38
No.50	18-33	18-33	16-29	16-29
No.100	10-21	10-21	9-20	9-20
No.200	5-15	5-15	5-12	5-12

C. **Mineral filler** shall be non-air entrained hydraulic cement, Type I, conforming to Section 214 of the Specifications or hydrated lime conforming to Section 240.02(a) of the Specifications. When requested by the Engineer a manufacturers Certification will be required.

D. **Water** shall conform to Section 216 of the Specifications.

E. **Latex modifier** along with emulsifiers shall be milled into the asphalt emulsion by an approved emulsion manufacturer.

F. **Additives** may be used by the Contractor to provide control of the break/set time in the field. The type of additive shall be specified in the mix design.

G. **Sampling requirements** for gradation shall be taken from aggregate stockpiles designated by the Contractor. These stockpiles shall be located in the aggregate producer's quarry and acceptance for gradation will be based on an approved aggregate Producer's modified acceptance production control plan. Samples for Marshall tests and asphalt content shall be taken from the completed mix for testing by the Department. The frequency of sampling and testing will be established by the Engineer based upon the Department's acceptance program. The asphalt content will be determined by the Ignition Method (VTM-102) or nuclear gauge (VTM-93), as determined by the Engineer.

III. MIX DESIGN

A. The mixture shall be designed in a Department approved lab by the Contractor for the Engineer's approval and the job mix formula shall provide the following:

1. Compatibility of latex, aggregate and emulsion according to the Schulze-Breuer Test procedure. Other procedures approved by the Engineer may be used. The test shall be run at the design stage and when requested by the Engineer.
2. A minimum Marshall Stability of 1800 pounds when tested according to VTM-95.
3. A flow of between 6 and 16 units when tested according to VTM-95.
4. An asphalt content that produces 4.7 percent voids in total mix for surface and 6.5 percent voids for rutfilling when tested according to VTM-95.

Aggregate used in the job mix formula shall be from the same source and representative of the material proposed by the Contractor for use on the project.

B. Proportioning of the mix design shall be within the following limits:

	Type A	**Type B**	**Type C**	**Rutfilling**
% Residual Asphalt (by wt. of dry aggr.)	6.5-8.5	6.5-8.5	5.0-7.5	4.5-6.5
% Mineral Filler	0.26-3.00	0.26-3.00	0.25-3.00	0.25-3.00
% Latex Modified-Solids (by wt. of residual asp.)	3.0 Min.	3.0 Min.	3.0 Min.	3.0 Min.
Additive	As required	As Required	As Required	As Required

IV. EQUIPMENT

All equipment, including hand tools, shall be designed or suitable for the application of micro-surfacing and in good working condition.

A. **Mixing equipment** shall produce the asphalt mixture in a self-propelled, front feed, continuous loading, and mixing machine. The unit shall deliver and proportion the aggregate, emulsion, mineral filler, control setting additive and water to a revolving multi-blade shafted mixer and discharge the mixture on a continuous and uniform basis. A mobile unit will be permitted on areas less than 15,000 square yards provided a sufficient number of units are used to promote an efficient continuous type operation which minimizes disruption to traffic and provided the units are equipped with a twin shaft mixer capable of an operational speed of 60 feet per minute and have a capacity to store and mix components to produce a minimum of 5 tons of mix. All equipment shall be capable of delivering a continuous, uniform, properly proportioned, and homogenous mixture to the spreading unit.

Individual volume or weight controls for proportioning each material shall be provided and meters or counters shall be such that the Engineer may readily and accurately determine the amount of each material used at anytime.

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box when required.

B. **Equipment calibration** shall be provided by the Contractor stating the current year data for each mixing unit using materials from the same sources as those to be used on the project. Data for each unit shall be in the form of a graphic scale indicating the proportioning controls settings required to obtain the residual asphalt content as determined in the mix design. Such data shall be maintained with each unit.

C. **Spreading equipment** shall uniformly spread the paving mixture by means of a mechanical type spreader box attached to the mixer and equipped to agitate and spread the materials throughout the box. The box shall be designed and operated so all the mixed material will be kept homogenous and moving with no evidence of premature breaking during laydown. A front seal shall be provided to ensure no loss of the mixture at the road contact surface. The rear flexible seal shall act as a final strike off and shall be adjustable. The spreader shall be maintained to prevent the loss of the paving mixture in the surfacing super-elevated curves. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved and produces a free flow of material to the rear strike-off without causing skips, lumps, ripples or tears in the finished surface. A secondary strike-off may be used to improve surface texture.

Rutfilling, when required, shall be accomplished by means of a box specifically designed for that purpose. The box shall be of one-half lane width and have a dual chamber with an inner v configuration of augers to channel the large aggregate to the center of the rut and the fines to the edges of the rut fill pass. The box shall be equipped with dual steel strike-off to control both the width and depth of the rutfill.

D. **Pneumatic roller** may be required by the Engineer, at no cost to the Department, if excessive loss of aggregate is observed. The roller shall be equipped with treaded tries having an air pressure of 40 – 60 pounds per square inch (psi).

V. PROCEDURES

A. **Beginning work**, The Contractor shall notify the Engineer at least three work days prior to beginning work. Up on request by the Department, the Contractor shall provide 6 quarts of liquid emulsion and 50,000 grams of aggregate material for the Department’s use in determining asphalt content. The contractor shall perform ignition oven calibrations and submit them with the job-mix formula (JMF) to the Department two weeks prior to the beginning of the work.

B. **Surface preparation**, prior to applying the paving mixture, the surface shall be thoroughly cleaned of all vegetation, loose materials, dirt, mud and other objectionable materials. Prior to paving, an asphalt tack coat Type CSS-1h diluted three parts water to one part asphalt shall be applied at a rate 0.05 gallons per square yard. When required by field conditions prewetting of the tacked surface shall be applied evenly at a rate that will uniformly dampen the entire roadway surface.

All cost for furnishing and applying the tack coat and prewetting shall be included in the price bid for “Latex Modified Emulsion Treatment”.

C. **Application types and rates**

1. Rutfilling shall be placed by means of a specially designed rutfilling box that will leave the surface crowned between 1/8 and 1/4 inch per inch depth to allow for traffic compaction to approximately a level surface. The Contractor shall provide and use a ten foot straight edge to control the depth and crown.
2. Latex Modified Emulsion Treatment for leveling course shall consist of an initial application to prepare for the surface course. The minimum application rates shall be 16 pounds per square yard for Type B and 20 pounds per square yard for Type C.
3. Latex Modified Emulsion Treatment (LMET) for surface course shall consist of the final application which serves as the pavement surface. The LMET shall be placed at an application rate of 16 to 20 pounds of mix per square yard for Type B and 18 to 22 pounds per square yard for Type C.

   Where neither rutfilling nor leveling is used, the mix application rates shall be 18 to 22 pounds per square yard for Type B and 20 to 24 pounds per square yard for Type C.

   The Contractor shall provide to the Engineer aggregate weight tickets, a daily delivery summary, and an estimate of aggregate lost and otherwise not used in the work for each stockpile location (rutfilling aggregate shall be stockpiled and inventoried separately). When disagreements occur, the Engineer will make the final determination of such loss.

D. **Application**

The mixture shall be spread to fill minor cracks and shallow potholes and leave a high-skid resistant surface uniform in texture and appearance. Longitudinal joints shall not overlap more than four inches, except on irregular roadway widths when approved by the Engineer; however the joints shall be neat in appearance. Pavement edges shall be reasonably straight and shall be tapered to tie in neatly at gutters, entrances, and connections. When possible, longitudinal joints shall be placed on lane lines.

During night paving operations sufficient lighting shall be provided by the Contractor to insure proper application of micro-surfacing.

Rutfilling must be compacted by traffic or by a minimum of three passes with a pneumatic tire roller not in excess of 5 miles per hour (mph) prior to application of the surface course and must be cured such that applied material is totally free of detectable water. Rutfilling or scratch courses placed at night shall not be overlaid the same night or until such time that the materials totally free of detectable water.

Any oversized aggregate or foreign materials shall be screened from the aggregate stockpile prior to delivery to the mixing machine. A mixing aid additive shall be used to accommodate spreading due to slow placements or high temperatures. Additionally, water in a very limited quantity may be sprayed into the sprayed box to prevent build-up on the blades. All excess material shall be removed immediately from the ends of each run. Loose aggregate that is determined to be objectionable by the Engineer shall be immediately removed without damaging the surface. Based upon a visual examination or test results the Engineer may reject any work due to poor workmanship, loss of texture, raveling or apparent instability. The entire area specified shall be treated and the contract quantity shall not be exceeded.

E. **Test requirements**

Samples representing a maximum of 500 tons will be taken from material produced by each mixing unit for asphalt content determination. The residual asphalt content of such samples shall be within plus or minus 1.5 percent of the approved job mix. When successive tests from a mixing unit fail or one test fails by more than two percent, that unit shall be removed from service until approved by the Engineer.

F. **Price Adjustment**

Emulsified asphalt certified weight tickets showing the residual asphalt content shall be provided to the Engineer. Asphalt not used shall be documented and considered in determining the percent of asphalt used on the total project. Upon completion of the project, the percent of asphalt shall be determined by dividing the calculated weight of residual asphalt by the delivery ticket weight of aggregate used in the work. A one percent reduction in the unit price per ton will be applied for each one tenth of a percent the residual asphalt content is more than one percent below the approved job mix formula. The price adjustment will be applied to the total tons for which payment is made.

G. **Weather Limitations**

Micro-surfacing shall not be applied on surfaces containing puddle water and on surfaces less than 50 degrees F, except that in the early morning the minimum surface temperature may be 40 degrees F provided the ambient temperature is expected to be above 60 degrees F and there is no forecast of ambient temperature below 32 degrees F within 24 hours from the time the material is applied.

H. **Personnel**

The Contractor shall have a Department certified Slurry Surfacing Technician on the job site to control the work.

VI. MEASUREMENT AND PAYMENT

The quantity of latex modified emulsion treatment used in the accepted portions of the work will be measured by net ticket weight of aggregate, latex modified emulsion and mineral filler delivered and incorporated in the accepted work. No deduction will be made for moisture naturally occurring in the aggregate and mineral filler.
The accepted quantity of **latex modified emulsion rutfilling** will be paid for at the contract unit price per ton.
The accepted quantity of **latex modified emulsion treatment** will be paid for at the contract unit price per ton for the type material specified.

Payment will be made under:

Pay Item	Pay Unit
Latex modified emulsion rutfilling	Ton
*Latex modified emulsion treatment, (Type)	Ton

*(For asphalt schedule work projects, the leveling and surfacing courses are shown as separate line items in the schedule of work but combine into one bid item in the schedule of items.)

APPENDIX D: NEW SPECIFICATION DEVELOPED IN THIS STUDY FOR MICROSURFACING

SQ312-000110-01

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
MICRO-SURFACING

August 18, 2021

I. DESCRIPTION

This work shall include furnishing and placing a Micro-Surface emulsion treatment to existing roadway surfaces as specified herein and as directed by the Engineer. A micro-surfacing is the application of a mixture containing polymer-modified emulsified asphalt, mineral aggregate, mineral filler, water, and other additives that are properly proportioned, mixed, and spread on a paved surface. Micro-surfacing shall be constructed on a prepared surface.

II. MATERIALS

A. **Emulsified asphalt** shall be a quick set latex modified cationic emulsion conforming to Section 210 of the Specifications and the following:

1. The emulsion shall be designated CQS-1hP cationic quick setting emulsion and shall conform to AASHTO M316

B. **Aggregate** shall be non-polishing crushed stone conforming to Section 202 of the Specifications, except the soundness loss shall not exceed 18 percent and the sand equivalency shall be no less than 65

C. **Mineral filler** shall be non-air entrained hydraulic cement, Type I, conforming to Section 214 of the Specifications or hydrated lime conforming to Section 240.02(a) of the Specifications. When requested by the Engineer a manufacturers Certification will be required.

D. **Water** shall conform to Section 216 of the Specifications.

E. **Polymer modifiers** along with emulsifiers shall be milled into the asphalt emulsion by an approved emulsion manufacturer.

F. **Additives** may be used by the Contractor to provide control of the break/set time in the field. The type of additive shall be specified in the mix design.

G. **Sampling requirements** for gradation shall be taken from aggregate stockpiles designated by the Contractor. These stockpiles shall be located in the aggregate producer's quarry and acceptance for gradation will be based on an approved aggregate poducer's modified acceptance production control plan. Samples for mix design verification tests and asphalt content shall be taken from the completed mix for testing by the Department. The frequency of sampling and testing will be established by the Engineer based upon the Department's acceptance program. The asphalt content will be determined by the Ignition Method (VTM-102) or nuclear gauge (VTM-93), as determined by the Engineer.

III. MIX DESIGN

A. The mixture shall be designed in a Department approved lab by the Contractor for the Engineer's approval and the job mix formula shall meet the requirements of AASHTO PP-83 *Standard Practice for Micro-Surfacing Design.*

Aggregate used in the job mix formula shall be from the same source and representative of the material proposed by the Contractor for use on the project. The gradation of the aggregate stockpile shall not vary from the mix design gradation by more than the stockpile tolerance, as defined by AASHTO MP-28 *Standard Specification for Materials for Micro Surfacing- Table 2*, while also remaining within the specification's gradations band.

IV. EQUIPMENT

All equipment, including hand tools, shall be designed or suitable for the application of micro-surfacing and in good working condition.

A. **Mixing equipment** shall produce the asphalt mixture in a self-propelled, front feed, continuous loading, and mixing machine. The unit shall deliver and proportion the aggregate, emulsion, mineral filler, control setting additive and water to a revolving multi-blade shafted mixer and discharge the mixture on a continuous and uniform basis. A mobile unit will be permitted on areas less than 15,000 square yards provided a sufficient number of units are used to promote an efficient continuous type operation which minimizes disruption to traffic and provided the units are equipped with a twin shaft mixer capable of an operational speed of 60 feet per minute and have a capacity to store and mix components to produce a minimum of 5 tons of mix. All equipment shall be capable of delivering a continuous, uniform, properly proportioned, and homogenous mixture to the spreading unit.

Individual volume or weight controls for proportioning each material shall be provided and meters or counters shall be such that the Engineer may readily and accurately determine the amount of each material used at anytime.

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box when required.

B. **Equipment calibration** shall be conducted by the Contractor, no more than 60 days prior to each trial section and provided to the Engineer prior to production, for each mixing unit using materials from the same sources as those to be used on the project. Data for each unit shall be in the form of a graphic scale indicating the proportioning controls settings required to obtain the residual asphalt content as determined in the mix design. Such data shall be maintained with each unit.

C. **Spreading equipment** shall uniformly spread the paving mixture by means of a mechanical type spreader box attached to the mixer and equipped to agitate and spread the materials throughout the box. The box shall be designed and operated so all the mixed material will be kept homogenous and moving with no evidence of premature breaking during laydown. A front seal shall be provided to ensure no loss of the mixture at the road contact surface. The rear flexible seal shall act as a final strike off and shall be adjustable. The spreader shall be maintained to prevent the loss of the paving mixture in the surfacing super-elevated curves. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved and produces a free flow of material to the rear strike-off without causing skips, lumps, ripples or tears in the finished surface. A secondary strike-off may be used to improve surface texture.

Rutfilling, when required, shall be accomplished by means of a box specifically designed for that purpose. The box shall be of one-half lane width and have a dual chamber with an inner v configuration of augers to channel the large aggregate to the center of the rut and the fines to the edges of the rut fill pass. The box shall be equipped with dual steel strike-off to control both the width and depth of the rutfill.

D. **Pneumatic roller** may be required by the Engineer, at no cost to the Department, if excessive loss of aggregate is observed. The roller shall be equipped with treaded tries having an air pressure of 40 – 60 pounds per square inch (psi).

V. PROCEDURES

A. **Beginning work**, The Contractor shall notify the Engineer at least three work days prior to beginning work. Up on request by the Department, the Contractor shall provide 6 quarts of liquid emulsion and 50,000 grams of aggregate material for the Department's use in determining asphalt content. The contractor shall perform ignition oven calibrations and submit them with the job-mix formula (JMF) to the Department two weeks prior to the beginning of the work.

B. **Surface preparation**, prior to applying the paving mixture, the surface shall be thoroughly cleaned of all vegetation, loose materials, dirt, mud and other objectionable materials. Cover service entrances (i.e., manhole covers, valve boxes) with an approved method. Prior to paving, an asphalt tack coat Type CSS-1h diluted three parts water to one part asphalt shall be applied at a rate 0.05 gallons per square yard. When required by field conditions prewetting of the tacked surface shall be applied evenly at a rate that will uniformly dampen the entire roadway surface.

All cost for furnishing and applying the tack coat and prewetting shall be included in the price bid for "Micro Surfacing".

C. **Test Strip**, The Contractor shall place a test trip prior to beginning of the work for approval by the Engineer, for each approved JMF. A test strip shall be constructed on the project site, if subsequent test strips are required, the Engineer may require it to be conducted off site. The length of the test strip shall be a minimum of 500 ft.

D. **Application types and rates**

1. Rutfilling shall use Type III and be placed by means of a specially designed rutfilling box that will leave the surface crowned between 1/8 and 1/4 inch per inch depth to allow for traffic compaction to approximately a level surface. The Contractor shall provide and use a ten foot straight edge to control the depth and crown.

2. Micro Surfacing for leveling course shall consist of an initial application to prepare for the surface course. The minimum application rates shall be 16 pounds per square yard for Type II and 20 pounds per square yard for Type III.

3. Micro Sufacing for surface course shall consist of the final application which serves as the pavement surface. The Micro Surfacing shall be placed at an application rate of 16 to 20 pounds of mix per square yard for Type II and 18 to 22 pounds per square yard for Type III.

   Where neither rutfilling nor leveling is used, the mix application rates shall be 18 to 22 pounds per square yard for Type II and 20 to 24 pounds per square yard for Type III.

The Contractor shall provide to the Engineer aggregate weight tickets, a daily delivery summary, and an estimate of aggregate lost and otherwise not used in the work for each stockpile location (rutfilling aggregate shall be stockpiled and inventoried separately). When disagreements occur, the Engineer will make the final determination of such loss.

D. **Application**

The mixture shall be spread to fill minor cracks and shallow potholes and leave a high-skid resistant surface uniform in texture and appearance. Longitudinal joints shall not overlap more than 3 inches, except on irregular roadway widths when approved by the Engineer; however the joints shall be straight and neat in appearance. Pavement edges shall be reasonably straight and shall be tapered to tie in neatly at gutters, entrances, and connections. When possible, longitudinal joints shall be placed on lane lines. All transverse joints shall be clean and straight. At the start of each day(s) of production and at approaches, place a minimum of 5 feet width paper/plastic on the existing pavement. Longitudinal edge line shall not vary by more than 2 inches in 100 feet.

During night paving operations sufficient lighting shall be provided by the Contractor to insure proper application of micro-surfacing.

Rutfilling must be compacted by traffic or by a minimum of three passes with a pneumatic tire roller not in excess of 5 miles per hour (mph) prior to application of the surface course and must be cured such that applied material is totally free of detectable water. Rutfilling or scratch courses placed at night shall not be overlaid the same night or until such time that the materials totally free of detectable water.

Any oversized aggregate or foreign materials shall be screened from the aggregate stockpile prior to delivery to the mixing machine. A mixing aid additive shall be used to accommodate spreading due to slow placements or high temperatures. Additionally, water in a very limited quantity may be sprayed into the sprayed box to prevent build-up on the blades. All excess material shall be removed immediately from the ends of each run. Loose aggregate that is determined to be objectionable by the Engineer shall be immediately removed without damaging the surface.

Based upon a visual examination or test results the Engineer may reject any work due to poor workmanship, loss of texture, raveling or apparent instability.

The entire area specified shall be treated and the contract quantity shall not be exceeded.

E. **Test requirements**

Samples representing a maximum of 500 tons will be taken from material produced by each mixing unit for asphalt content and gradation determination. The residual asphalt content of such samples shall be within plus or minus 1.5 percent of the approved job mix. Per the gradation tolerances in AASHTO, when successive tests from a mixing unit fail or one test fails by more than 2 percent, that unit shall be removed from service until approved by the Engineer.

F. **Price Adjustment**

Emulsified asphalt certified weight tickets showing the residual asphalt content shall be provided to the Engineer. Asphalt not used shall be documented and considered in determining the percent of asphalt used on the total project. Upon completion of the project, the percent of asphalt shall be determined by dividing the calculated weight of residual asphalt by the delivery ticket weight of aggregate used in the work. A one percent reduction in the unit price per ton will be applied for each one tenth of a percent of the residual asphalt content is more than one percent below the approved job mix formula.

The price adjustment will be applied to the total tons for which payment is made.

G. **Weather Limitations**

Micro-surfacing shall not be applied on surfaces containing puddled water and on surfaces less than 50 degrees F; or when the amient temperature is below 50 degrees F. Micro Surfacing shall not be applied if the forecast of ambient temperature is below 32 degrees F within 24 hours from the time the material is applied.

H. **Personnel**

The Contractor shall have a Department certified Slurry Surfacing Technician on the job site to control the work.

VI. MEASUREMENT AND PAYMENT

The quantity of Micro-Surfacing used in the accepted portions of the work will be measured by net ticket weight of aggregate, modified emulsion and mineral filler delivered and incorporated in the accepted work. No deduction will be made for moisture naturally occurring in the aggregate and mineral filler.

The accepted quantity of **Micro-Surfacing - rutfilling** will be paid for at the contract unit price per ton.

The accepted quantity of **Micro-Surfacing, (Type)** will be paid for at the contract unit price per ton for the material type specified.

Payment will be made under:

Pay Item	**Pay Unit**
Micro-Surfacing - rutfilling	Ton
*Micro-Surfacing, (Type)	Ton

*For asphalt schedule work projects, the leveling and surfacing courses are shown as separate line items in the schedule of work but combine into one bid item in the schedule of items.

APPENDIX E: NEW SPECIFICATION DEVELOPED IN THIS STUDY FOR FOG SEALS

SQ312-000115-00

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
EMULSIFIED ASPHALT FOG SEAL

August 20, 2021

I. DESCRIPTION

This work shall include applying emulsified asphalt fog seal material to existing or new roadway surfaces as specified herein and as directed by the Engineer.

II. MATERIALS

A. **Emulsified asphalt** shall be designated CSS-1h conforming Section 210 of the Specification. Fog seal emulsified asphalt may be diluted with water prior to application but no more than 2 days before application. Fog seal emulsified asphalt shall be diluted with water by the ratio of 1:1 at the emulsified asphalt plant and not on the project site.

B. **Blotter Aggregate** shall be non-polishing crushed stone conforming to Section 202 of the Specifications when used. The gradation to be used is shown in the table below unless required in the plan or the contract.

Screen Size	% Passing
No.8	100
No.16	50–85
No.30	25–60
No.50	5–30
No.200	0–10

C. **Water** shall conform to Section 216 of the Specifications.

III. EQUIPMENT

A. **Asphalt Distributor** shall be calibrated by the Contractor Contractor in the presence of the Enginee prior to application. The Contractor shall submit the proof of the calibration to the Engineer. Asphalt distributors shall be equipped with proper spray nozzles including end nozzles for the application rate specified, to provide uniform coverage throughout the width of the application. The spray bar nozzles shall produce a uniform double or triple lap application fan spray, and the shutoff shall be instantaneous, with no dripping. All nozzles shall be oriented at the same angle between 15 and 30 degree.

B. **Motorized Brooms** with controlling vertical pressure shall be used to clean the road surface prior to spraying emulsified asphalt.

IV. PROCEDURES

A. **Target application rate** for the fog seal shall be following the table below. The Contractor shall construct a 500 foot test strip to review and adjust the application rate as needed, and demonstrate the uniform coverage of the fog seal.

Type	Residual Rate	Diluted 1:1
Application Rate, gal/yd^2	0.015–0.021	0.05–0.07

B. **Beginning work**, the Contractor shall clean the roadway surface by sweeping no more than 30 min prior to application of the fog seal unless otherwise approved by the Engineer. The roadway surface shall be dry.

C. The Contractor shall request the Engineer's approval if blotter aggregate is needed to absorb any excess emulsified asphalt and provide friction. The typical application rate is 1–3 lbs/yd^2. A self-propelled mechanical aggregate spreader capable of distributing the aggregate uniformly at the designed rate shall be used.

V. ACCEPTANCE

Blotter aggregate sample taken from the aggregate spreader hopper once per day shall be submitted to the Department for testing (AASHTO T 27). Emulsified asphalt sample taken from the distributor shall be submitted to the Department when requested by the Engineer. The traffic shall not be allowed before the fog seal has cured and the blotter aggregates have been applied if used.

VI. WEATHER LIMITATION

The Contractor shall not place the fog seal when the ambient temperature below 40 degree F is anticipated within 24 hrs. The Contractor shall apply the fog seal when the ambient and pavement temperature above 60 degree F and rising during daylight hours.

VII. MEASUREMENT AND PAYMENT

Fog Seal will be measured in gallons and will be paid for the the Contract gallon price. The volume will be based on daily volume with temperature corrections in accordance with Section 109. The Contractor shall report the quantity using the TL 143 Method B form.

Blotter Aggregate will be measured and paid for at the contract unit price per ton under cover material.

Payment will be made under:

Pay Item	Pay Unit
Fog Seal	Gallon
Cover Material	Ton

APPENDIX F: PHOTOGRAPHS FROM NEARBY CHIP SEAL ROUTES WITH DISTRESS

Figure F.1. Nearby Chip Seal Routes Demonstrating Aggregate Loss and Bleeding

APPENDIX G: MICROSURFACING MIX DESIGNS FOR REFERENCE AND DEMO SECTIONS

Reference Section

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
Statement of Asphalt Concrete or Central-Mix
Aggregate Job-Mix Formula

Submit to the District Administrator. Virginia Department of Transportation. Approval must be received by th contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of t Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. ________ Design Lab No. 3822

Date 4-22-2022 Job Mix ID No. LM-2022-07 Calendar Yr. 202

Type Mix/Size Aggregate Latex Modified Emulsion Treatment "Type C" TSR Test No. N/A

Producer Name & Plant Location Asphalt Emulsion, Inc., Richmond, VA for Slurry Pavers Inc. Phone (804)264-0707

MATERIALS		Kind	Source
Aggregate	%		
PolyFibers	%		
Lime	As Needed %	Hydrated Lime	Greer Lime, Riverton, WV or VDOT Approved Source
Sand	%		
Screening	99 %	Granite	Martin Marietta, (Anderson Creek Quarry, Rockville VA)
Lime/ Cement	.25-3 %	Portland Type I Cement or	Lehigh Cement, Union Bridge, MD or VDOT Approved Source(used in lieu of Hydrated Lime as necess
Asphalt Cement			
Asphalt Emulsion		CQS-1H LM	Asphalt Emulsion, Inc., Richmond, VA
Additives:			
Water	As Needed %	Potable	Local Sources
	%		

JOB-MIX Sieves	Total % Passing	Tolerance % ☒ or -	Acceptance Range Average of ____ Test(s)	Design /Spec. Range
3/8	100.0		100.0	100.0
4	94		70-95	70-95
8	66		45-70	45-70
16	43		32-54	32-54
30	28		23-38	23-38
50	18		16-29	16-29
100	11		9-20	9-20
200	6.8		5-12	5-12

Asphalt	7.5 %	+/- 1.5 %	6.0-9.0	7.0-9.5
Temperature	° F + 20° (+ 11 ° C)			

Correction Factor for Ignition Oven -0.40
Producer Technician's Certification Number ________

MATERIALS DIVISION USE ONLY

Remarks All materials have been tested and approved according to VAAP

Nominal Max Size Aggr. ________ Application Rate: Min. ________ Max. ________

Compacted unit weight of the mix. at the job mix asphalt content ________ VTM ________ Max. Sp. Gr. ________

Checked By ________

Approved tentatively subject to the production of material meeting all other applicable requirements of specification.

Copies:
State Materials Engineer
District Materials Engineer
Project Inspector
Sub-Contractor and/or Producer

Approved By Sanchez, Anthony P. (Tone)
District Materials Engineer

I. AGGREGATE REPORT

SPECIFICATION: VA Type C

SIEVE	% PASSING	SPECIFICATION
3/8	100	100
#4	94	70-95
#8	66	45-70
#16	43	32-54
#30	28	23-38
#50	18	16-29
#100	11	9-20
#200	6.8	5-12

PARAMETER	RESULT
Bulk Specific Gravity:	2.616
Effective Specific Gravity:	2.761
Correction Factor:	0.152
Absorption, %:	1.98

II. MARSHALL TEST REPORT

PARAMETER	RESULT		
% Residual – Mix:	4.8	6.1	7.0
% Residual – Aggregate:	5.0	6.5	7.5
Average Stability, lbs:	3085	3162	3488
Average Flow, 0.01 in:	14.2	15.0	15.2
Average Voids Total Mix, %:	13.2	7.6	4.7
Average Voids Mineral Aggregate, %:	19.3	19.3	16.6
Average Voids Filled with Asphalt, %:	31.6	60.9	70.5
Average Bulk Specific Gravity:	2.261	2.292	2.392
Maximum Theoretical Specific Gravity	2.604	2.480	2.515

III. SCHULZE-BREUER COMPATIBILITY

PARAMETER	RESULT	STATUS
Water Absorption, %:	5.1	PASS
Abrasion Loss, %:	3.9	PASS

IV. DESIGN RESIDUAL AT 4.7% VTM

% Residual by Weight of Aggregate:	7.5

Demonstration Section

NCHRP Demo
on LMSA Schedule

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
Statement of Asphalt Concrete or Central-Mix
Aggregate Job-Mix Formula

Submit to the District Administrator. Virginia Department of Transportation. Approval must be received by th contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of t Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. ____________ Design Lab No. 4322

Date 6-14-2022 Job Mix ID No. 2022-04 Calendar Yr. 2022

Type Mix/Size Aggregate: Micro Surfacing "Type III" AASHTO SPEC. TSR Test No. N/A

Producer Name & Plant Location: Asphalt Emulsion, Inc., Richmond, VA for Slurry Pavers Inc. Phone (804)264-0707

MATERIALS	%	Kind	Source
Aggregate	%		
PolyFibers	%		
Lime	As Needed %	Hydrated Lime	Greer Lime, Riverton, WV or VDOT Approved Source
Sand	%		
Screening	99 %	Granite	Luck Stone, Ruckersville VA, Greene Plant
Lime/ Cement	1 %	Portland Type I Cement or	Lehigh Cement, Union Bridge, MD or VDOT Approved Source(used in lieu of Hydrated Lime as necess
Asphalt Cement			
Asphalt Emulsion		CQS-1H LM	Asphalt Emulsion, Inc., Richmond, VA
Additives:			
Water	As Needed %	Potable	Local Sources
	%		

JOB-MIX Sieves	Total % Passing	Tolerance % ☒ or -	Acceptance Range Average of ___ Test(s)	Design /Spec. Range
3/8	100.0		100.0	100.0
4	81	–	70-90	70-90
8	59	–	45-70	45-70
16	45	–	28-50	28-50
30	36 ✓	2% out	19-34	19-34
50	27 ✓	2% out	12-25	12-25
100	18	–	7-18	7-18
200	9.6		8-15	8-15

Asphalt	7.5 %	+/- 1.0 %	6.5-8.5	6.5-8.5
Temperature		°F + 20° (+ 11 ° C)		

Correction Factor for Ignition Oven -0.19

Producer Technician's Certification Number ____________

MATERIALS DIVISION USE ONLY

Remarks: All materials have been tested and approved according to VAAP

Nominal Max Size Aggr. ________ Application Rate: Min. 22 lbs/yd² Max. ______

Compacted unit weight of the mix. VTM ________ Max. Sp. Gr. ________

at the job mix asphalt content ________

Checked By R. E. Byram

Approved tentatively subject to the production of material meeting all other applicable requirements of specification.

Copies:
State Materials Engineer
District Materials Engineer
Project Inspector

Approved By R. E. Byram on behalf of T. R. Tate
District Materials Engineer DME

I. AGGREGATE GRADATION

SPECIFICATION: AASHTO TYPE III

SIEVE	% PASSING	SPECIFICATION
3/8	100	100
#4	82	70-90
#8	54	45-70
#16	37	28-50
#30	29	19-34
#50	23	12-25
#100	17	7-18
#200	9.5	8-15

II. MIX EVALUATION[1]

Test Procedure	Test Result	Specification
Mixing Time, 25°/77°F, seconds (TB 102)	300	min 120
Set Time Test, 30 min, kg-cm (TB 139)	16	min 12
Early Rolling Traffic Time, 60 min, kg-cm (TB 139)	23	min 20
Wet Track Abrasion Loss, g/m^2, 1-hour soak (TB 100)	204	max 538
Wet Track Abrasion Loss, g/m^2, 6-day soak (TB 100)	468	max 807
Lateral Displacement, % (TB 147)	1.9	max 5
Excess AC by Sand Adhesion, g/m^2 (TB 109)	282	max 538
Wet Stripping Test, % Coated (TB 114)	>95	min 90
Saturated Abrasion Loss, g (TB 144)	0.79	max 1.0

[1]Aggregate and emulsion samples utilized in this evaluation were tested under laboratory conditions. Adjustments in the formulation may be required for conditions at the time of application.

III. JOB MIX FORMULATION

Component	Design	Tolerance
Mineral Filler, %	1.0	+/-1.0
Water, %	As Required	As Required
Residual Asphalt, %	7.5	±0.5

APPENDIX H: PHOTOGRAPHS FROM ADDITIONAL CHIP SEAL DEMONSTRATION SECTION

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