

# Micro Surfacing Quality Construction

State-of-the-Practice

Nevada Department of Transportation Maintenance Division, 1263 S. Stewart St. Carson City, NV 89712

## TECH BRIEF

This document is a brief technical summary on micro surfacing preservation treatments which is included in a larger report, ***State-of-the-Practice in Chip Seal, Slurry Seal, Micro Surfacing and Thin Lift Asphalt Overlay Construction Quality Assurance*** (Report No. 715-15-050). This Tech Brief provides information on micro surfacing specifications and construction practices. It then summarizes the state-of-the-practice elements that could lead to quality construction.

### Introduction

Micro surfacing “consists of a mixture of polymer-modified emulsified asphalt, mineral aggregate, water, and additives, proportioned, mixed and uniformly spread over a properly prepared surface.”<sup>(1)</sup> This Tech Brief summarizes the specification and construction state-of-the-practice for three agencies: the California Department of Transportation (Caltrans), the Minnesota Department of Transportation (MnDOT), and the Virginia Department of Transportation (VDOT). The agencies were selected based on agency experience, construction volume, and reported performance. All of these elements were determined using surveys and interviews. The standard micro surfacing specifications for these agencies are summarized and compared.<sup>(2-5)</sup> Additionally, one case study is presented.

### Micro Surfacing Pre-Construction Considerations

The actual pre-construction considerations are beyond the scope of this study. However, these considerations are the first step in achieving a well-performing micro surfacing treatment. These include project selection based on pavement condition, pavement age, traffic, and climate. Such considerations should be used in a decision matrix or decision tree to determine which preservation treatment is the appropriate treatment to use on a particular pavement.

---

## Micro Surfacing Specifications

Caltrans, MnDOT, and VDOT appear to have effective specifications and special provisions for micro surfacing. The micro surfacing specification summary for all three agencies are presented in Table 1.

### *Materials.*

All three agencies specify a latex-modified quick-set emulsion. MnDOT specifies a CQS-1hP emulsion grade. VDOT specifies a quick set latex-modified emulsion of unspecified grade. All of the materials are blended in the mix design at similar proportions. All three agencies specify similar aggregate gradation types. These gradations follow the International Slurry Surfacing Association's (ISSA's) recommended gradation guidelines, with some minor variations present in the sieve size ranges. Additionally, Caltrans does not specify a percentage passing range for No. 50 and No. 100 sieves.

Caltrans and MnDOT both use the ISSA gradation type naming convention (Type I, II, III), whereas VDOT uses separate identifiers (Type A, B, C, Rut-filling). It is important to note that the ISSA standard does not have a Type I micro surfacing type, so this gradation is added by each agency. The Maximum Aggregate Sizes (MAS) for all three agencies' micro surfacing types are No. 4 for Type I/A, 3/8 inch for Type II/B, 3/8 inch for Type III/C and 3/8 inch for VDOT's Rut-filling mix. Caltrans and MnDOT use similar materials quality tests—namely, Sand Equivalent and L.A. Abrasion, whereas VDOT uses polish-resistant aggregate meeting Soundness, Void Content, Organic Impurities and Deleterious Materials requirements, which may aid

in the use of a durable, non-reactive and long-lasting aggregate.

### *Mix Design and Verification.*

All three agencies require the Contractor to provide the mix design for approval. The mix design material proportions are specified in terms of dry weight of aggregate.

Caltrans and MnDOT both specify the ISSA mix design method and verification tests. Both agencies specify using the recommended materials proportion ranges stated in the ISSA design standard (5.5-10.5% residual asphalt, 0-3% mineral filler, and water and additives as needed) with the following exceptions: Caltrans reduces the maximum residual asphalt content to 9.5%, and MnDOT increases the minimum mineral filler content to 0.25%.

The verification tests include Wet-Stripping, Wet-Track Abrasion Loss after 1-hour soak, Wet-Track Abrasion Loss after 6-hour soak, Saturated Abrasion Compatibility test, Mix Time at 77°F, and Mix Time at 100°F. Additionally, tests such as Lateral Displacement and Lateral Displacement Specific Gravity after 1000 cycles of 57 kg are also used. The required test result values for each agency are the same as those suggested in the ISSA micro surfacing design standard.<sup>(1)</sup>

VDOT specifies an internally-created mix design method and mix verification tests and requires the Contractor to conduct mix design in a VDOT-approved laboratory. The materials proportions vary by type of micro surfacing. For Type A micro surfacing, the residual asphalt content must be between 5.5-6.5% and mineral filler must be from 0.26-3%. For Type B

**Table 1. Micro Surfacing Specifications Summary.**

Elements of Specifications <sup>a</sup>	Caltrans	MnDOT	VDOT
Asphalt Binders	Emulsions—polymer-modified, no specific grade.	Emulsions—CQS-1P, CQS-1hP.	Emulsions—CSS-1h. Uses CQS-1h, conforming to CSS-1h requirements. Latex-modified.
Aggregates	Sand and/or crushed rock dust.	Volcanic rock.	Crushed gravel and/or stone.
Mix Design/Verification	ISSA Mix Design Method—includes tests; Agency verification tests.	ISSA Mix Design Method—includes tests; Agency verification tests.	Agency Mix Design Method; Agency verification tests.
Equipment and Calibration	Both equipment and calibration details.	Either equipment or calibration details.	Either equipment or calibration details.
Calendar Date/Climate Limits	Temperature limits only.	Calendar dates and temperature limits.	Temperature limits only.
Inspection	Inspection of application rates.	Inspection of application rates; Test strip performed; Monitor mixture consistency.	Inspection of application rates; Monitor mixture consistency.
Opening to Traffic	Opening to traffic 1-2 hrs.	Opening to traffic 1-2 hrs.	Not specified.
Quality Control	QC includes materials testing.	QC includes materials testing.	QC includes materials testing.
Acceptance	Acceptance includes materials testing.	Acceptance includes materials testing.	Acceptance includes materials testing.

<sup>a</sup>Information obtained from standard specifications, published documents, and phone interviews.

micro surfacing, the residual asphalt content must be between 6.5-8.5% and mineral filler must be from 0.26-3%. For Type C micro surfacing, the residual asphalt content must be between 5.0-7.5% and mineral filler must be from 0.25-3%. For Rut-filling micro surfacing, the residual asphalt content must be between 4.5-6.5% and mineral filler must be from 0.25-3%. Some of the mix verification tests make use of some of the tests used in the Marshall Mix Design method, including Marshall Stability and Flow, Compatibility, VMA and Asphalt Content.

***Climate and Surface Preparation.***

For all three agencies, the surface and air temperatures must be at least 50°F and rising. This is to ensure that the micro surfacing will cure within the required time frame. Surface preparation includes cleaning the surface of all deleterious material, covering exposed roadway structures and, in some conditions, fogging the

surface with water ahead of the spreader box during construction. Proper surface preparation ensures the bond of the treatment with the existing pavement. MnDOT and VDOT both specify a diluted CSS-1h emulsion tack coat as part of the surface preparation. The MnDOT application rate is 0.05-0.10 gal/yd<sup>2</sup>, while VDOTs is 0.05 gal/yd<sup>2</sup>. This is done to aid in improving the bond between the treatment and pavement. Caltrans recommends repairing wheel path depressions (such as rutting and potholes) as a part of surface preparation, which may aid in reducing rutting.

***Equipment.***

All three agencies specify equipment details for a truck-mounted or self-propelled continuous mixer, a standard spreader box or special spreader box, and hand tools. VDOT also specifies that a pneumatic-tire roller may be used. The recommended industry standard is to calibrate equipment prior to the

construction of every project. Caltrans specifies that each mixing unit is to be calibrated in the presence of the Engineer prior to construction. Two agencies specify, at a minimum, yearly calibration data collection. One of those agencies also specifies that the equipment be re-calibrated after any repairs have been made to the proportioning equipment.

All three agencies specify that application rates be verified during construction. All three agencies have provisions for adjustment of application rates at the direction of engineer. VDOT

specifies that the application rate is verified using aggregate weight tickets taken from the truck upon delivery of the aggregate to the job site. Additionally, VDOT specifies screening the aggregates for oversized particles prior to entering the pugmill. This prevents streaking in the finished surface due to dragging of individual oversized particles.

**Inspection.**

Table 2 shows some of the primary inspection practices that are used by the agencies.

**Table 2. Construction Inspection requirements.**

Inspection Item	Caltrans	MnDOT	VDOT
<b>Calibration</b>	Conducted five business days before construction.	Calibrated once per year or after repairs are made to the equipment.	Calibration data from current calendar year. Calibration done with same materials to be used on project.
<b>Monitor Application Rate</b>	Must be within 10% of target rate.	Not specified.	Verified by Engineer with weight tickets.
<b>Test Strip Requirements</b>	Not specified.	One lane-width-wide, 1,000 feet long, applied one hour after sunset or one hour before sunrise. Production begins after test strip accepted.	Not specified.
<b>Spread rate ranges</b>	Type I: 8-12 lb/yd <sup>2</sup> Type II: 10-15 lb/yd <sup>2</sup> Type III: 20-25 lb/yd <sup>2</sup>	Not specified.	Type B: 16 lb/yd <sup>2</sup> minimum; 16-20 lb/yd <sup>2</sup> for surface; 18-22 lb/yd <sup>2</sup> for rut-filling or levelling. Type C: 20 lb/yd <sup>2</sup> minimum; 18-22 lb/yd <sup>2</sup> for surface; 20-24 lb/yd <sup>2</sup> for rut-filling or levelling.

**Test Strip Requirements.**

The recommended industry standard is to construct test strips prior to construction for every project. Some items that a test strip checks for are:

- Check the materials proportion optimization and that the

proportions are kept within job mix formula (JMF) tolerances.

- Verify the application rate.
- Check for uniformity of surface texture.
- Ensure that the equipment is in good condition.

- 
- Ensure that the workforce is well trained.
  - Check the cure time.
  - Evaluate workmanship.
  - Ensure proper alignment of the equipment.

Test strips should be conducted under conditions that are representative of those anticipated during construction. It should be placed using the same process and equipment to be used during construction. MnDOT test strip requirements include minimum length and timing of the test strip's placement. MnDOT specifies three spot checks within the test strip section to make sure that curing is achieved after one hour.

#### ***Opening to Traffic and Post-Construction Monitoring.***

Caltrans and VDOT specify that the treatment is not to be opened to traffic until it has cured to the extent that it will not be picked up by vehicle tires. MnDOT specifies that the treatment must be opened within one hour of construction. On the first day of construction, the MnDOT Engineer will perform three one-hour spot checks of the finished treatment surface to ensure that the treatment has cured. If all three pass, the spot check frequency is reduced to once per day. Currently, all three agencies require the Contractor to maintain the treatment post-construction until final acceptance. VDOT monitors the performance of micro surfacing treatments at the network level.<sup>(7)</sup>

#### ***Quality Assurance.***

All three agencies specify Quality Assurance (QA) provisions during construction. Caltrans specifies extensive submittal requirements for

Contractors, including full mix testing and Quality Control (QC) testing of individual materials. MnDOT specifies that the Contractor's emulsion and aggregate suppliers are to perform testing on the individual materials, with the complete mix being tested by the Contractor prior to construction. VDOT specifies that the complete mix be sampled from the mixing machine during construction and tested for residual asphalt content. This is done as part of QC and Acceptance. Aggregate is also subjected to QC testing, with samples taken directly from the material stockpiles.

#### ***Acceptance.***

Acceptance practices among the three agencies focusses primarily on the quality of the individual materials in the mix. Caltrans accepts the micro surfacing aggregate based on Sand Equivalent and gradation. MnDOT also tests Contractor-submitted aggregate samples for gradation and Sand Equivalent. This is conducted prior to production as a part of Acceptance. VDOT accepts the micro surfacing mix based on testing of the asphalt content using two separate Virginia test methods—VTM-102—*Determination of Asphalt Content from Asphalt Paving Mixtures by the Ignition Method – (Asphalt Lab)* and VTM-93—*Nuclear Asphalt Content Gauge Determination for H.M.A. and Slurry Seal Mixtures – (Asphalt Lab)*.<sup>(8,9)</sup> Table 3 and Table 4 display the primary QC and Acceptance testing practices specified by all three agencies.

**Table 3. Contractor Quality Control Sampling & Testing Requirements.**

Test Type	Caltrans	MnDOT	VDOT
<b>Mix Design (Pre-Production)</b>	One JMF, submitted 10 days prior to production.	Complete 1 Job Mix Formula per mix.	One JMF, submitted two weeks prior to production.
<b>Production Gradation</b>	Not specified.	One per 1,000 ton with a minimum of one per day.	Sampled from stockpiles designated by Contractor.
<b>Aggregate Moisture Content</b>	Not specified.	One per 1,000 ton with a minimum of one per day.	Not specified.
<b>Asphalt Binder</b>	Not specified.	QC testing is the responsibility of the bituminous material supplier. Random sampling is arranged by the MnDOT Chemical Laboratory.	Not specified.
<b>Asphalt Content</b>	Not specified.	Not specified.	Once per 500 tons.
<b>Asphalt Binder Application Rate</b>	Not specified.	Verified three times per day.	Not specified.

**Table 4. Agency Acceptance Sampling and Testing Requirements.**

Test Type	Caltrans	MnDOT	VDOT
<b>Production Gradation</b>	Once per day or 300 tons.	Once at production.	Sampled from stockpiles designated by Contractor
<b>Aggregate Moisture Content</b>	Not specified.	Once per day	Not specified.
<b>Sand Equivalent</b>	Once per day or 300 tons.	Once per project (pre-production)	Not specified.
<b>Cleanness Value</b>	Once per day or 300 tons.	Not specified.	Not specified.
<b>Asphalt Binder</b>	Not specified.	On first load, then once per 50,000 gal.	Not specified.
<b>Asphalt Content</b>	Not specified.	Not specified.	Once per 500 tons.
<b>Asphalt Binder Application Rate</b>	Not specified.	Verified once per day.	Not specified.

### Case Study: VDOT Micro Surfacing Project

VDOT provided documentation for the purposes of developing a case study based upon a micro surfacing project that was constructed from March 2014 to May 2014. The placement occurred on three routes—Caroline County route VA-207, Richmond and Northumberland County US-360, and Lancaster County

route VA-200. All three routes are two-lane rural arterials.

VDOT provided several types of construction records, including mix design records, emulsion tank reports, asphalt mixture laboratory tests, and application rate checks.

Submitted mix design records indicate that the mix designs were created in

March 2013. The materials consisted of 3/8-inch MAS granite aggregate (Type C), CQS-1h-LM latex modified emulsion (6.9% residual asphalt by dry weight of aggregate), Type 1 Portland Cement (1.0% by dry weight of aggregate), and a control additive. The target application rate reported on all three JMFs was 24 lb/yd<sup>2</sup>. The JMF can be seen in Table 5.

The emulsion supplier submitted 29 certified asphalt emulsion test reports dating from March 14 to May 12. Each report includes the supplier's batch number, product name, quantity, and production date as well as the date sampled, name of the technician taking the sample, and the technician performing the tests. Test results are reported for sieve test, particle charge, residual asphalt percent, residual asphalt penetration, and residual asphalt softening point. All tests

complied with applicable VDOT specifications. For example, residual asphalt ranged from 62% to 64.4% (minimum 62%), and ring & ball softening point ranged from 60.0°C to 71.0°C (minimum 60°C).

VDOT provided 6 mixture test reports ranging from sample dates of March 20 to May 2. The reports identify the project, route, sample number, truck load number, and laboratory receiving date. The report also listed the lot quantity associated with each sample mix (typically 500 ton). The reports list aggregate gradation and residual asphalt content test results. The residual asphalt content ranged from 5.84 to 7.22% (JMF range is 5.4 to 8.4%). The P-200 ranged from 11.6 to 14.1%, which is at or above the target range of 5% to 12%.

**Table 5. JMF for VDOT Micro Surfacing Projects**

Micro Surfacing Mix Properties	Results at 6.5% Residual Asphalt	Specification, Type C
Average Marshall Stability, VTM-95	3,163 lb	1,800 lb Minimum
Average Marshall Flow, VTM-95	0.14 inch	0.06-0.16 inch
Average Voids in Total Mix	5.3%	4.7%
Average VMA	18.3%	Not specified
Asphalt Absorption	1.89%	Not specified
Water Absorption, Schulze-Breuer	7.0%	Not specified
Abrasion Loss, Schulze-Breuer	3.2%	Not specified
Ignition Oven Correction Factor	0.042	Not specified
Gradation (Percent Passing)		
Passing 3/8 inch	100	100
Passing No. 4	85	70-95
Passing No. 8	55	45-70
Passing No. 16	39	32-54
Passing No. 30	30	23-38
Passing No. 50	24	16-29
Passing No. 100	16	9-20
Passing No. 200	8.9	5-12

VDOT provided 11 aggregate application rate reports beginning on March 20 and ending May 9. Each report included the project identification,

inspector's name, truck number, the spreader's aggregate calibration number (aggregate pounds per count), aggregate count for the period, area

---

covered, and computed aggregate spread rate. The spread rate over the 11 reports ranged from 19.77 lb/yd<sup>2</sup> to 27.08 lb/yd<sup>2</sup>. VDOT specifies an application rate of 20 to 24 lb/yd<sup>2</sup> for Type C micro surfacing mix.

Projects records were not able to be obtained to include information on placement temperature, equipment calibration, and time to open to traffic.

Key practices that led to a quality VDOT project included:

- Overall project size.
  - A total of 200,000 yd<sup>2</sup> of micro surfacing was placed across all three routes.
- Requiring a mix design.
- Requiring quality assurance during construction.
  - Emulsion and aggregate testing.
  - Residual asphalt content verification.
  - Routine checks of mix application rates.

### **State-of-the-Practice**

The recommended state-of-the-practice for micro surfacing preservation treatments includes:

- Selecting quality asphalt binder and aggregate materials.
  - Latex-modified emulsion.
  - ISSA aggregate property tests are specified along with agency-specific tests.
- Performing a micro surfacing mix design for the materials to be used during construction.
  - The ISSA mix design method is a common micro surfacing mix design standard.

- Calibrating equipment with the materials to be used during construction.
  - Recommended to be done prior to every project.
- Proper surface preparation to achieve a clean surface to obtain bond between the pavement surface and the micro surfacing.
- Constructing a test strip.
  - Recommended to be done on every project, under conditions similar to those that are anticipated during construction.
- Requirements for contractor's QC testing during construction.
  - Aggregate production gradation and moisture content, asphalt binder property, residual asphalt binder content, and mix application rate.
- Requirements for agency Acceptance sampling and testing during construction.
  - Aggregate production gradation, moisture content, sand equivalent, and cleanness.
  - Emulsion and residual asphalt binder properties, residual asphalt binder content, and mix proportions.
  - Testing of mix proportions requires measuring the actual quantities of emulsion and aggregates used. If measured, they could be direct pay items. This can be challenging because of the need for weigh scales at the project. Thus, emphasizing the need for proper and frequent calibration if scales are not practically available.
- Enforcing appropriate climatic conditions during construction.
  - Minimum surface and air temperatures of 50°F and rising.



- 
- Wintertime construction shutdowns.
  - No impending precipitation within, typically, the next 24 hours to 72 hours.
  - Ensuring proper curing prior to opening the treatment to traffic.

An additional consideration that can support quality micro surfacing

construction includes the use of qualified and/or certified personnel for:

- Conducting micro surfacing mix designs.
- Constructing micro surfacing treatments.
- Inspecting micro surfacing during construction.
- Field testing the micro surfacing mix and materials.

### **Additional Information**

For additional information, contact this project's principal investigator Elie Y. Hajj, Ph.D. at the University of Nevada, Reno.

### **References**

1. ISSA A143: *Recommended Performance Guideline for Polymer-Modified Micro Surfacing*, International Slurry Surfacing Association, 2005, Rev. 2010, 16 pp.
2. California Department of Transportation (Caltrans), "2015 Revised Standard Specifications," 2015.
3. Minnesota Department of Transportation (MnDOT), "Standard Specifications for Construction," 2016.
4. Virginia Department of Transportation, "Special Provisions for 2016 Road and Bridge Specifications," 2016.
5. Virginia Department of Transportation, "2016 Road and Bridge Specifications," 2016.
6. Caltrans Division of Construction, Material Plant Quality Program, California Department of Transportation, July 2008, Rev. 2015, 46 pp.
7. Minnesota Department of Transportation (MnDOT), "Schedule of Materials Control for 2016 Standard Specifications," 2016.
8. Virginia Test Methods VTM-102—*Determination of Asphalt Content from Asphalt Paving Mixtures by the Ignition Method – (Asphalt Lab)*, prepared for the Virginia Department of Transportation, December 2013, pp. 288-298.
9. Virginia Test Methods VTM-93—*Nuclear Asphalt Content Gauge Determination for H.M.A. and Slurry Seal Mixtures – (Asphalt Lab)*, prepared for the Virginia Department of Transportation, November 2000, pp. 250-252.

### **Additional Reference**

ISSA, *MA-1 Inspector's Manual: 2010 Edition*. This document covers slurry seals materials, mix design, equipment calibration in the field, sampling at the site, inspection responsibilities and procedures, safety, surface preparation, stockpiling procedures, problems that may occur, their potential causes, solutions to those problems, and other suggestions.

---

**Researchers**—This study was performed by the University of Nevada, Reno, in collaboration with the National Center for Asphalt Technologies at Auburn University.

**Funding**—This study was sponsored by the U.S. Federal Highway Administration.

**Key Words**—Flexible Pavement, Micro Surfacing, State-of-The-Practice, Quality Construction, Quality Assurance, Inspection, Specifications.

**Availability**—The report is available from the Nevada Department of Transportation Library at <https://www.nevadadot.com/doing-business/about-ndot/ndot-divisions/planning/research/library>

**Disclaimer**—The contents of this document reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of Nevada or the U.S. Department of Transportation, Federal Highway Administration, at the time of publication. This report does not constitute a standard, specification, or regulation.