Alaska Department of Transportation & Public Facilities

Minnesota Drive Ramps Microsurfacing Experimental Feature

Post-Construction Report

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Statewide Materials

October 2020

Prepared For:

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DISCLAIMER

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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Minnesota Drive Ramps Microsurfacing

Experimental Feature

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Statewide Materials and Asset Management

October 2020

Table of Contents

Definitions 2
Executive Summary 3
Introduction 4
Project Scope 4
Experimental Feature 6
Preconstruction Site Inspection 7
Application Method 12
Construction 14
Monitoring Plan 20
Observations and Results 20

Appendix

Pre-Construction Documentation .... Appendix A
Construction Photolog .... Appendix B
Materials Testing .... Appendix C
Ramp Removal Photolog and Friction Tests .... Appendix D
Experimental Feature Work Plan .... Appendix E

Figures

Figure 1 - Microsurfacing Location Map 5
Figure 2 - Microsurfacing Material Flow 12

Tables

Table 1 - Microsurfacing Ramps 4
Table 2 - Friction Testing Results 20
Table 3 - AADT and Truck Traffic 21

Photos

Photo 1 – Ramp 1 Prior to Surface Preparation Photo 2 – Ramp 1 After Surface Preparation 8
Photo 3 - Ramp 8 General Condition Photo 4 - Ramp 9 General Condition 9
Photo 5 - Ramp 11 Prior to Surface Preparation Photo 6 - Ramp 12 - Cracks after Surface Preparation.......10
Photo 7 - Ramp 15 After Surface Preparation 11
Photo 8 - Ramp 16 After Surface Preparation 11
Photo 9 - VSS Macropaver 12B Unit 12
Photo 10 - Secondary Strike Off and Hand Working..........13
Photo 11 - Hand Worked Area on Ramp 6..........13
Photo 12 - Pneumatic Roller on Test Strip..........15
Photo 13 - Bubbles from Slurry on Test Strip 17
Photo 14 - Ramp 1 Flushing Distress Photo 15 - Ramp 2 Flushing Distress 18
Photo 16 - Ramp 2 Flushing Distress..........19

Definitions

AASHTO	American Association of State Highway Transportation Officials
DFT	Dynamic Friction Tester
DOT&PF	Department of Transportation and Public Facilities
HMA	Hot Mix Asphalt
IRI	International Roughness Index – units of inches/mile
ISSA	International Slurry Seal Association
Jnr	Non-Recoverable Creep Compliance Parameter of MSCR Test
MSCR	Multiple Stress Creep Recovery
PG	Performance Grade
QAP	Quality Asphalt Paving
SBR	Styrene Butadiene Rubber
SBS	Styrene Butadiene Styrene
TB	Technical Bulletin
VSS	Valley Slurry Seal

Executive Summary

During the 2020 construction season the Department of Transportation and Public Facilities (DOT&PF) installed its first application of microsurfacing at 17 locations on Minnesota Drive ramps in Anchorage. The total area applied was 26,231 square yards.

Microsurfacing is a preservation treatment that can be applied in thin layers (1/3" or less) and consists of a mixture of fine aggregate, emulsion and additives. It offers the potential to be a more economical solution to the typical mill and fill treatment that is used to address rutted roads in Central Region.

While this treatment is used widely in the contiguous United States, it has not been used on roads in Central Region due to poor historical Prall testing (ATM 420) that is used to simulate studded tire wear. A new formulation of microsurfacing was evaluated in 2016 with significantly improved performance on the Prall test. This formulation uses fine aggregate and a high residual binder content (10%-11%) using a PG64-40 modified binder with between 6%-8% SBS polymer, which is a very high percentage for a microsurfacing treatment. In 2017 the ramps on Minnesota Drive were selected for evaluating the microsurfacing treatment with this formulation as part of the larger Minnesota Drive: Seward to Tudor Pavement Preservation Project (CFHWY00106) as an experimental feature.

This application required surface preparation, including crack sealing and hot mix asphalt (HMA) tamped in place for cracks greater than ¾", a tack coat, then a scratch course of microsurfacing to fill ruts and other surface deviations with the final wearing course being placed over the scratch course.

Construction took place in June of 2020. The primary contractor was Quality Asphalt Paving (QAP), with Colas performing the mix design. The microsurfacing application was sub-contracted to Valley Slurry Seal (VSS) out of California as no crews or equipment are locally available in Alaska.

On the first day of production, June 7th, it was discovered the crude source for the base binder had changed since the mix design had been performed over the winter. The change in crude source caused an unacceptably long set time and a problem applying the microsurfacing in super elevated curves. This required a change in the additives used in the formulation and a slight delay to the project as the proper dosages in the new formulation were determined. A new test strip and mix design were performed.

Production resumed June 10th starting with a new test strip, which was successful. Production continued without issue and the application was completed June 13th.

On June 18th Construction noted a flushing distress on two of the International Airport ramps, where it appeared the coarse aggregate was depressed and the binder and fines were flushed to the surface, causing a loss of friction and the surface to appear shiny. The ramps were investigated and this distress was noted on seven ramps in varying severity.

Three of the seven ramps were noted to be a part of a haul route for borrow material being transported to Anchorage International Airport, and these three ramps had the highest severity flushing observed during the immediate days after installation. As microsurfacing uses an emulsion it gains strength as the water leaves the system and the heavy trucks on the fresh microsurfacing likely caused this distress while the system was still gaining strength.

In August 2020 the observed flushing distresses was considered to be severe enough to perform friction testing on five of the seven ramps, which validated the observed loss of friction. Those ramps are scheduled to be removed by mill and fill in September 2020 and the remaining ramps performance will be monitored for the following three years.

Introduction

The DOT&PF installed the first application of microsurfacing in Central Region during the 2020 construction season as part of the Minnesota Drive: Seward to Tudor Pavement Preservation Project (CFHWY00106). Microsurfacing is a preservation treatment that can be applied in thin lifts (1/3" or less) with the potential to offer the region significant cost savings over typical hot mix asphalt mill and fill applications of 2" thickness used to address studded tire wear. Microsurfacing is a system composed of fine aggregate, emulsion and additives. The aggregate used on this project is ISSA (International Slurry Seal Association) Type II aggregate, which is 3/8" minus with the aggregate primarily passing the #8 sieve. The emulsion used is CSS-1P and is highly polymer modified.

Although this treatment has been widely used in the contiguous United States, it has not been used on roads in Central Region of Alaska due to poor historical Prall test results on microsurfacing samples to simulate the effect of studded tire wear. However, Central Region has tested a new microsurfacing formulation in 2016 that performed well on the Prall test. With this confirmation of performance, Central Region selected the Minnesota Drive Ramps in 2017 for evaluating this treatment and it was constructed in June of 2020.

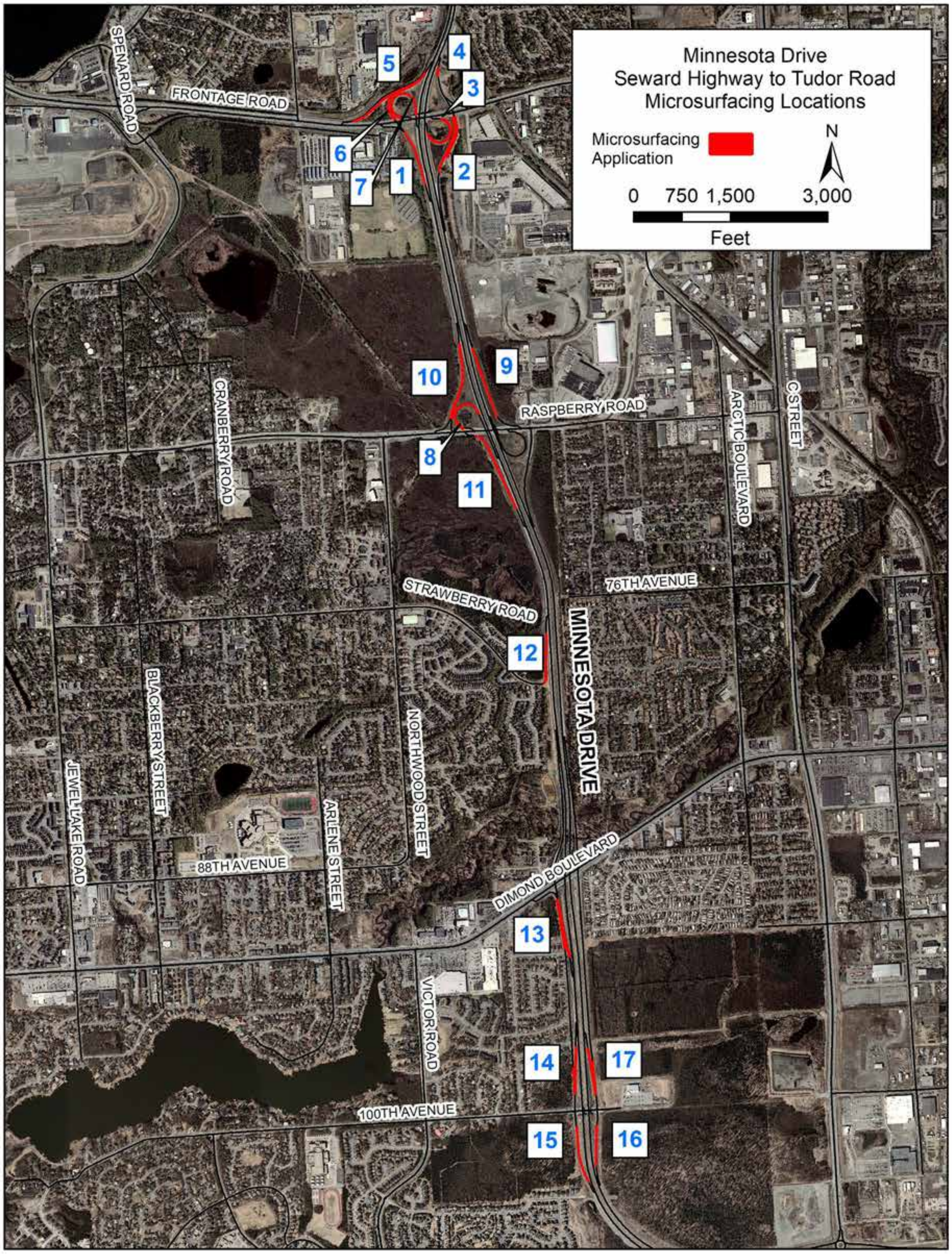
Project Scope

Microsurfacing was applied at 17 locations on Minnesota Drive Ramps, for a total of 26,231 SY surface course and 26,237 SY scratch course. All ramps received crack seal and fine hot mix tamped in place for cracks exceeding ¾" in width. Three locations received rut fill using fine hot mix pavement prior to the microsurfacing placement as the ruts were near to or exceeding 1" in depth. The microsurfacing was placed within the existing lane lines and did not extend onto the shoulders.

Table 1 - Microsurfacing Ramps

Ramp Name	Ramp Number	2019 AADT
International Airport EB - Minnesota WB On Ramp	1	4,995
Minnesota NB - International Airport Ramp	2	6,901
International Airport EB - Minnesota NB Loop	3	3,428
International Airport - Minnesota NB Ramp	4	2,926
Minnesota SB - International Airport Ramp	5	7,100
Minnesota SB - International Airport Ramp	6	5,852
International Airport WB - Minnesota SB Loop	7	1,401
Raspberry WB - Minnesota SB Ramp	8	1,020
Raspberry WB - Minnesota NB Ramp	9	1,441
Minnesota SB - Raspberry WB Ramp	10	5,862
Raspberry EB - Minnesota SB Ramp	11	2,902
Minnesota SB - Strawberry Ramp	12	1,825
Dimond - Minnesota SB Ramp	13	3,528
Minnesota SB - 100th Ramp	14	2,576
100th Avenue Minnesota SB Ramp	15	1,405
Minnesota NB - 100th Ramp	16	3,668
100th Avenue - Minnesota NB Ramp	17	2,967

Figure 1 - Microsurfacing Location Map



Experimental Feature

While microsurfacing has been widely used in the Lower 48, Alaska does not have proven performance with this pavement preservation technique. Traditionally, microsurfacing uses a stiff binder (PG 64-22, PG 58-28), while this project specified a binder with a PG of 64-40 which uses Kraton modifiers to achieve a high polymer content between 6%-8%, providing resistance to thermal cracking in cold temperatures with the -40 level and resistance to plastic deformation with the high polymer content. The -40 PG level was selected over -34 as Prall testing on hot mix asphalt has indicated that softer binders provide superior studded tire wear resistance. Prall testing on hot mix asphalt also indicated that higher binder contents with these softer binders improved studded tire wear resistance.

The Prall test is a test for abrasion caused by studs on hot mix asphalt. It tests a cylindrical specimen 100mm in length and 30mm in height, abrading the specimen by impacting it with 40 stainless steel balls for 15 minutes at near-freezing temperature. The resulting value is the loss of material in cubic centimeters, meaning the lower the number the better the results.

In 2016, Prall tests were performed on Type II microsurfacing samples with 16% emulsion and 13% emulsion contents using the same base binder specifications as used on this project. The Prall results came back with abrasion values of 19.5 cm^3 for the 16% emulsion and 27 cm^3 for the 13% emulsion, indicating that the microsurfacing performance behaves similarly to hot mix asphalt when using the Prall test and that the higher emulsion content would provide superior studded tire wear resistance. This project specified the Type II aggregate and higher emulsion content because of the testing performed.

While lab testing indicated this formulation would resist studded tire wear, the possibility that it could perform differently in the field remained. The microsurfacing mix design is very dependent on the chemistry of the materials being used, including the base binder and the aggregate. The Prall testing had been performed on specimens prepared using aggregates and binders from the Lower 48. The microsurfacing in this project used binders and aggregates that were locally available, and therefore used a different formulation and mix design than the samples originally prepared and tested.

Additionally, the Prall testing simulates the impact of the studs, not the scratching or plucking action of the studs. Field performance is required to truly see if microsurfacing will hold up to studded tire wear in the Anchorage area.

With this product being new to Alaska, DOT&PF was uncertain about its material performance in our harsh conditions and wanted to study its performance. Specifically, the Department wanted to study the impacts of:

- Studded tire wear
- Plastic deformation (load related rutting)
- Winter plowing operations
  - Plow trucks will run their blades as close to the pavement surface as possible to ensure clean, safe roads during the winter season. This may cause damage to the treatment.
- Freeze-thaw cycle (i.e. cracking, spalling, delamination)

Other aspects of this project that are considered experimental include:

- The high SBS (styrene butadiene styrene) polymer content used (between 6%-8%)
    - Typically the upper range of emulsification for this polymer is 3% as it is difficult to emulsify, and the Kraton polymer used is one of the only SBS polymers (if not the only one) that can be physically emulsified at a high dosage level in the base binder.
        - The Kraton polymer was used on this project because it is able to be emulsified at the high polymer content that is required for the residual binder to meet the AASHTO T-350 Multiple Stress Creep Recovery (MSCR) Jnr and Percent Recovery specifications used on this project.
    - Typically SBR (styrene butadiene rubber) latex is used as it is in the water phase and is easily emulsified, but has an upper limit of 4% polymer before its adhesion to aggregate is impacted, limiting its dosage beyond that point. With SBS the polymer is in the asphalt phase which makes it more difficult to break down into an emulsion by shearing through a colloid mill due to the adhesion of the base binder.
- The softness of the binder
    - Typically binders used for microsurfacing are stiff, such as a PG64-22 binder. The binder used in this project graded out at PG64-37 which has a lower end than is typically used, making it softer for cracking resistance.

The primary objectives of the Experimental Feature Monitoring Plan are to:

1. Assess existing asphalt conditions.
2. Assess surface preparation and material application during construction.
3. Monitor microsurfacing performance.
4. Make recommendations on future microsurfacing project consideration in Alaska.

Details of this plan can be found in Appendix E: Work plan for Microsurfacing Project.

Preconstruction Site Inspection

The project entered construction in fall 2019 and the ramps pre-construction conditions were assessed, but the microsurfacing was delayed to 2020 to allow for optimal summer construction weather. The preconstruction assessment was updated in spring 2020 and the ramp conditions varied in condition from being optimal candidates for pavement preservation with only minor surficial raveling, to ramps with severe longitudinal/frost cracks and the onset of fatigue-based cracking.

The specification called for hot mix asphalt to be tamped in place for cracks wider than ¾”, and for ease of construction cracks were sealed for the smaller cracks, with both crackseal and HMA used for wider cracks. Portions of three ramps had ruts increase in depth to over 1” by the summer of 2020, and hot mix was used for rut fill at these locations prior to the microsurfacing being placed. These were Ramps 1, 10, and 13, and the exact locations that received the overlay can be found in the appendix.

General ramp preconstruction conditions are provided below and include photos taken both before and after surface preparation was performed. See Appendix B for detailed information, including photos, maps of distress locations and of rut, roughness and cracking conditions.

Ramp 1: International Airport EB – Minnesota WB On-Ramp

The primary distresses is high severity longitudinal cracking down the center and right of the lane starting near International Airport Road. There is low raveling, and studded tire wear that deepens near the bottom of the ramp near Minnesota, which received rut fill using hot mix. At the end of the guardrail, pattern cracking has formed around the cracks. The cracks are near 1.5" at the widest and received crackseal and HMA to fill. The photo on the left is prior to surface preparation, and the right is after, with the larger crack being filled with both crackseal and hot mix.

Photo 1 – Ramp 1 Prior to Surface Preparation

Photo 2 – Ramp 1 After Surface Preparation

Ramp 2: Minnesota NB – International Airport Ramp

This ramp has low rutting for the majority of the ramp. The ruts deepen to near ¾" at the International Airport intersection. There are low to moderate severity transverse cracks, with one high severity transverse crack near International Airport Road.

Ramp 3: International Airport EB – Minnesota NB Loop

The primary pavement distresses are occasional low severity raveling and transverse cracking. There is one moderate severity transverse crack near the middle of the ramp, but looks to be an ideal pavement preservation candidate.

Ramp 4: International Airport – Minnesota NB Ramp

The end of this ramp has low severity rutting and low severity longitudinal and transverse cracking.

Ramp 5: Minnesota SB – International Airport Ramp

This ramp contains high severity longitudinal cracking near Minnesota Drive. An earthquake repair incorporated into this project addressed the worst of the longitudinal cracking near the middle of the ramp. After the earthquake repair, which ends near where Ramp 6 extends to International Airport road, the ramp is in much better condition, with only transverse cracking being the pavement distress.

Ramp 6: Minnesota SB International Airport Ramp

The primary distress on this ramp is longitudinal cracking of moderate severity, with one high severity crack near International. There is low severity rutting and low to moderate severity raveling.

Ramp 7: International Airport WB – Minnesota SB Loop

This ramp is a cloverleaf with low severity rutting and raveling. There is moderate severity transverse cracking where some potholes have formed. There is slippage cracking that may be caused by slope movement midway down the ramp near an earthquake repair patch.

Ramp 8: Raspberry WB – Minnesota SB Ramp

This cloverleaf ramp has block cracks of moderate severity for nearly the entire length along with a wide joint crack. Fatigue based cracking is beginning to appear in the wheel paths in addition to the block cracking. See photo below to the left that shows the general ramp condition.

Photo 3 - Ramp 8 General Condition

Photo 4 - Ramp 9 General Condition

Ramp 9: Raspberry WB – Minnesota NB Ramp

A longitudinal joint crack is present for the majority of the ramp, along with block cracking that has developed into alligator cracking in the right wheel-path that extends to near the end of the ramp at the International Airport sign. From then on, faint block cracking is beginning to develop along with moderate severity transverse cracks. See the photo above and to the right.

Ramp 10: Minnesota SB – Raspberry WB Ramp

There is high severity rutting near Minnesota (approximately 1" in depth) that received rut fill. The ruts outside of that area are approximately ½" in depth, not requiring additional treatment. There are high severity transverse and longitudinal cracks midway down the ramp.

Ramp 11: Raspberry EB – Minnesota SB Ramp

The predominant distresses are low to moderate severity thermal cracking and a low density joint that is raveling and losing aggregate. Potholes have been forming at the transverse cracks, with two major potholes approximately 50' from the end of the microsurfacing near Minnesota. There is intermittent longitudinal cracking on the ramp. See the photo below and to the left.

Photo 5 - Ramp 11 Prior to Surface Preparation

Photo 6 - Ramp 12 - Cracks after Surface Preparation

Ramp 12" Minnesota SB – Strawberry Ramp

There is high severity longitudinal cracking and potholing beginning approximately halfway down the ramp. Transverse cracking varies between low to high severity throughout the ramp. See the above right photo.

Ramp 13: Dimond – Minnesota SB Ramp

The majority of this ramp has ruts below ½", but where the ramp merges into Minnesota and traffic is actively accelerating, the ruts increase in depth to between ¾" to 1". Moderate severity raveling and transverse cracks are also present. The area that merges into Minnesota received rut fill to address the rutting.

Ramp 14: Minnesota SB – 100th Ramp

The rut depths are low, but there is high severity longitudinal cracking near 100th Avenue.

Ramp 15: 100th Avenue – Minnesota SB Ramp

There is high severity longitudinal cracking for the first 200' of the ramp near 100th Avenue. There is also moderate to high severity joint raveling consistently along the ramp that has opened up to near ¾" in width. High severity transverse cracking is present where the ramp ties into Minnesota.

Photo 7 - Ramp 15 After Surface Preparation

Ramp 16: Minnesota NB – 100th Ramp

There is high severity longitudinal cracking near 100th Avenue. The rut depths are low and raveling is low severity and isolated to joints. High severity transverse cracking is located near the Minnesota end of the ramp.

Photo 8 - Ramp 16 After Surface Preparation

Ramp 17: 100th Avenue – Minnesota NB Ramp

There is high severity transverse cracking, joint cracking and raveling at 100th Avenue. The rut depths are approximately ½", and increase in depth near Minnesota to nearly ¾".

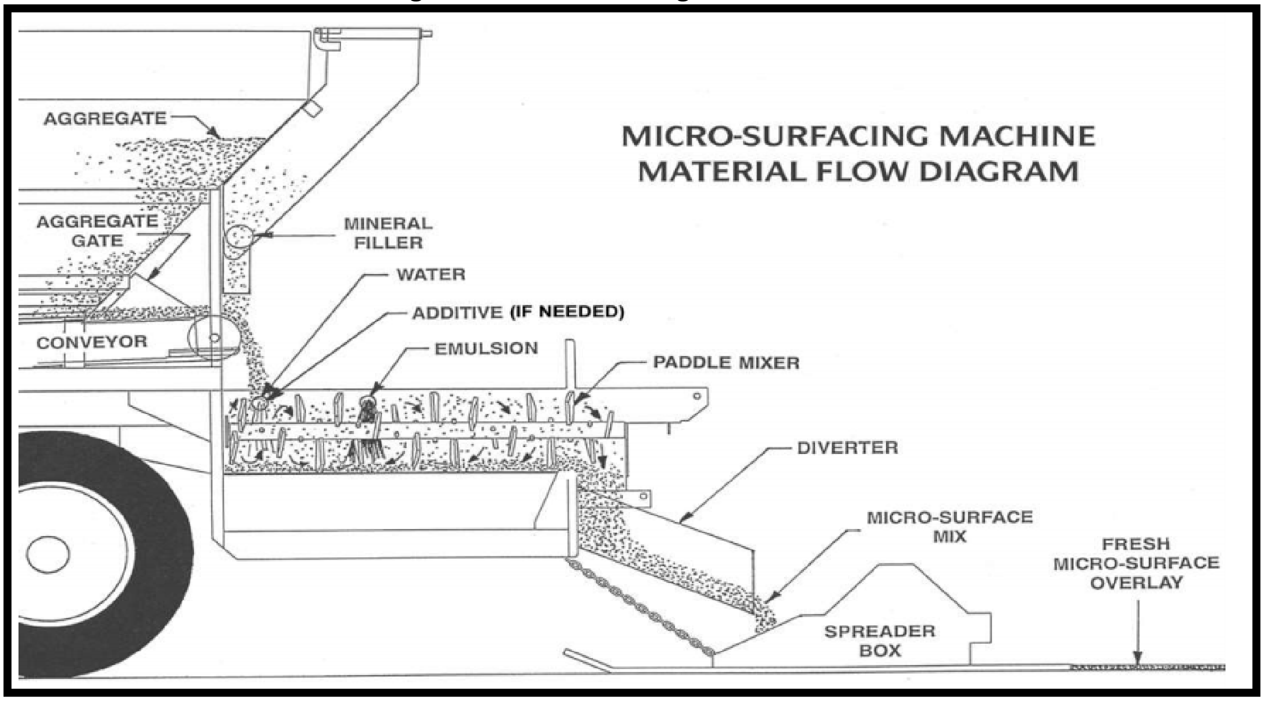
Application Method

Microsurfacing is a mix of fine aggregate, additives, and emulsion that are combined and applied at specific rates within the vehicle before the slurry reaches the spreader box and is applied onto the road surface. The equipment used for this application were two Valley Slurry Seal (VSS) Macropaver 12B units.

Photo 9 - VSS Macropaver 12B Unit

The typical material flow through microsurfacing equipment is shown in the diagram below.

Figure 2 - Microsurfacing Material Flow



Source: Ingevity – North Dakota Asphalt Conference – Future of Micro Surfacing, 2018

The sack on the end of the spreader box (see photo below) is used for secondary strike-off to provide surface texture on the final microsurfacing overlay and remove surface defects.

It takes approximately 90 seconds for the materials to be mixed, travel through the Macropaver unit and enter the spreader box through the diverter. The crew will hand work the microsurfacing using a squeegee at locations it is hard for the equipment to access, as well as remove drag marks and other surface imperfections (shown in the picture to the left.) The photo on the right is an example of an area that was hand worked at the intersection of Ramp 6 and International Airport Road.

Photo 10 - Secondary Strike Off and Hand Working

Photo 11 - Hand Worked Area on Ramp 6

This project required the surface be tack coated prior to the microsurfacing application to create a bond between the scratch course and the existing pavement and aid in resisting the lateral forces from traffic on the ramps.

After the tack coat, the scratch course was applied to fill ruts and provide a level application for the surface course. Most ramps had ruts less than ½” in depth, and the scratch course was able to fill these without requiring the use of a rut fill box, which was not required on this project. Three ramps did contain areas with ruts exceeding ¾” in depth and were considered enough of a concern to be addressed by using hot mix asphalt as rut fill. The length of rut fill performed was 1,000 feet.

The surface course was placed over the scratch course as the final wearing surface.

Construction

This project entered construction in the fall of 2019, which is the start of the rainy season. After discussions with DOT construction, the contractor, Quality Asphalt Paving (QAP) and Colas, who would be performing the mix design, it was decided to wait for the summer of 2020 to construct the microsurfacing and allow for optimal construction conditions.

Colas contacted Alaska DOT during the winter and expressed concerns about the set time of the microsurfacing relating to the softness of the PG64-40 binder. Colas proposed using a base PG64-34 binder in place of the PG64-40 binder, and this change would be accepted based on Prall results from samples using the proposed PG64-34 binder. Specimens were also provided using the PG64-40 base binder to compare results between the two formulations. The abrasion results came back at 14.9 cm^3 for the PG 64-40 binder, and 16.4 cm^3 for the PG64-34 binder. These results were considered acceptable and the change to using the PG64-34 binder was allowed.

Alaska does not have any microsurfacing contractors so QAP sub-contracted the work to Valley Slurry Seal (VSS) out of California. VSS mobilized up to Alaska on June 4^{th} and the test strip was performed on June 6^{th}.

Test Strip – June 6^{th}

The test strip was constructed at 1pm in QAP's yard off of C Street and 68^{th} Avenue in Anchorage. The weather was sunny with temperatures in the high 50's to low 60's. VSS used two Macropaver units, so both of them performed a test strip. The emulsion temperature was approximately 120 degrees F, and used 0.5% of lime instead of the intended 1% as the emulsion had recently been produced and the temperature was still higher than the intended 80 degrees F to be used in production. The higher temperature increases the reaction speed between the lime and microsurfacing material, and in this case the full 1% lime with 120 degree emulsion would reduce the workability of the material and prevent placement. Once the emulsion temperature was reduced to 80 degrees F in production, the full dose of lime would be used.

Three test strips were performed. The initial test strip was placed prior to DOT&PF staff arriving on site. This test strip was performed to ensure the equipment was working properly and the slurry was acceptable. The pavement conditions for the first two test strips were in good condition. They were smooth with minimal ruts and distresses, while the third test strip had some areas with minor depressions.

This formulation using highly modified PG64-34 base binder is considered a slow-set system, meaning without mechanical assistance the set time would take a few hours. To improve the set time, pneumatic rollers are used to mechanically force the water out of the microsurfacing. The water brought to the surface by the pneumatic rolling on the test strip can be observed in the photo on the next page.

Photo 12 - Pneumatic Roller on Test Strip

It was intended for the pneumatic roller to finish rolling the mat within an hour of application so traffic would be able to return to the ramp shortly after. However, it took slightly over two hours for the pneumatic roller to begin rolling the test strip without damaging the fresh microsurfacing. The Department was informed this was due to the high emulsion temperature and the reduced lime content and that, with the full lime dosage and cooler emulsion, the pneumatic would be able to begin rolling the mat sooner.

The test strips were approved conditionally on the set time being reduced, and were to be reviewed the next day in production.

Production – June 7th

Production began at 9:30am after the ramps had been tacked with STE-1. The weather was sunny and 55 degrees F, rising to 60 degrees F by the end of production.

The microsurfacing scratch course was first applied to Ramp 1, the International Airport EB – Minnesota SB Ramp, beginning at the base of the ramp and applying uphill toward International. The initial microsurfacing was applied over an area that had been rut filled with hot mix, which extended for 400'. The scratch course was then applied over approximately 50' of pavement with rut depths between ½" and ¾", which decreased to approximately ½" for the rest of the ramp.

The second ramp to receive the scratch course was Ramp 6, the Minnesota SB – International Airport Ramp. The scratch course was then placed on the western portion of Ramp 5, Minnesota SB – International Airport WB Wye. The ruts and surface deviations were minimal on both of these ramps were not exceeding ½”.

A problem was encountered during the application on the western side of the Wye portion of the ramp. This ramp has a moderately superelevated curve, requiring the spreader box to be filled with additional material to be able to apply a full lane width in this section. If not filled sufficiently, the spreader box would have the slurry pool to one side, not giving a full lane width application. In this case, when the box filled, the mix began to break, requiring the equipment to stop and clean the breaking/clumping material out. In the next pass the equipment was able to finish application on this portion of the ramp.

The equipment moved to the eastern portion of Ramp 5 and ran into a similar problem in the superelevated section of the ramp, with the spreader box and material clumping. This time however, the equipment was unable to proceed after cleaning out the spreader box. The other Macropaver unit attempted to place the microsurfacing at this location and encountered the same problem.

Initially, it was thought the high polymer content in the slurry was clogging a valve in the Macropaver. However, after evaluation and testing by Colas and the mix design expert on site, it was discovered the crude source for the binder had changed since the mix design was performed over the winter. This affected the chemistry of the microsurfacing, and the lime was not reacting as expected with the emulsion to break and set the slurry at the expected times, causing it to become chunky in the spreader box at super elevated locations preventing placement.

The mix design expert had gone to the lab to determine possible solutions, and over two hours had passed since the first scratch course had been placed. Upon returning to the ramp, the pneumatic roller had been unable to begin rolling the ramp. This ramp appeared to be taking longer to set than the test strip, and when the pneumatic roller had attempted to roll the ramp it had experienced pickup, damaging the fresh mat. After 3.5 hours the roller was able to roll the 400’ that had been rut filled, but after proceeding onto the area with the ¾” ruts it once again experienced pickup.

The observations made at this time showed that the microsurfacing appeared to be curing from the top down, instead of the bottom up, as it should be. There was a slightly hardened crust at the surface that appeared to be trapping water in the system that was delaying the set time far too much.

After 4 hours the roller was able to proceed up the ramp and finish rolling the remaining ramps without issue. The set time on these ramps was unacceptable, but Colas and the mix design expert had determined that aluminum sulfate and cement worked in place of lime with the binder from the new crude source, and this increased the break time from 30 seconds to 120 seconds. This would allow the material to pass through the Macropaver, which takes 90 seconds, and for 30 seconds in the spreader box for placement through the superelevated areas prior to the slurry beginning to break. This change in formulation would also provide faster set times to allow traffic to return to the ramps sooner.

This change was allowed conditionally on a new mix design being submitted and a new test strip being performed. The next day, June 8^{th}, experienced rain in the forecast and was determined to be a weather day. This allowed for time to refine the microsurfacing formulation in preparation for the new test strip.

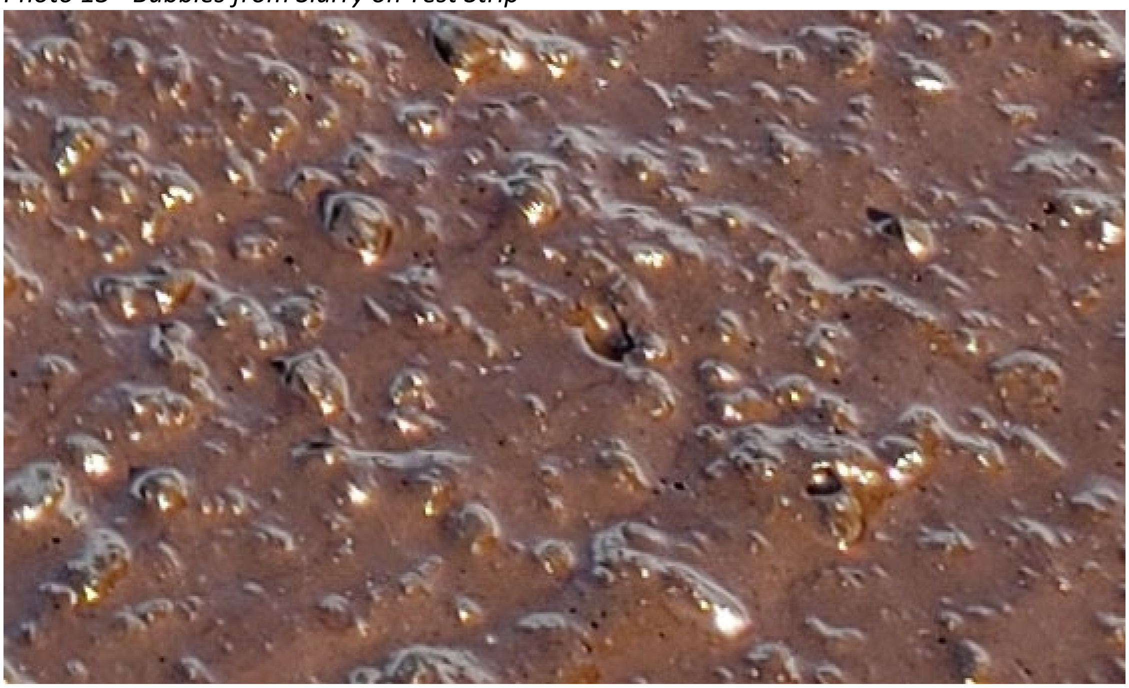
Production and Test Strip– June 10th

Both June 8th and 9th experienced rain, and the production resumed on June 10th with the new test strip in QAP's yard.

The weather was partly cloudy, and the test strip started at 10am with temperatures increasing up to 65 degrees over the course of the day. The new microsurfacing formulation removed the 1% lime and replaced with 2% cement and 1% aluminum sulfate to adjust the pH level.

After the microsurfacing was placed on the test strip, small holes/bubbles were observed on the surface which were not seen with the previous formulation using lime. This indicates water is escaping the system as it sets and, while difficult to see, can be observed in the photo below.

Photo 13 - Bubbles from Slurry on Test Strip



After 1.5 hours the roller was able to begin rolling and mechanically curing the system. While the 1.5 hours was over the 1 hour window desired to get the roller on the microsurfacing, it would be a drastic improvement over the 4 hours experienced previously, and the test strip was considered successful. The crews mobilized back to Minnesota Drive to finish the International Airport Ramps and then move to the Raspberry Ramps.

The portions of Ramps 5 and 6 that had been left unfinished received the scratch course using the new microsurfacing system, and no issues were experienced through the superelevated portion that had previously caused issues.

The equipment then moved to Ramp 11, the Raspberry EB – Minnesota SB Ramp. This ramp had some ruts near 0.75" near the middle of the ramp where traffic would be accelerating prior to preparing to merge, but was in otherwise good condition. The microsurfacing was applied without issue on this ramp as well as Ramp 7, the International Airport WB - Minnesota SB Loop cloverleaf ramp that required application in significant superelevations.

The rollers were able to get on all the ramps within 1.5 hours as had been experienced on the test strip and production continued using this formulation.

Production – June 11th, 12th and 13th

Contacted the project and it seemed to be going well and remaining on track. Production ended on June 13th. The only issue encountered was some roller pickup on Ramp 2, the Minnesota NB - International Airport Ramp, which was remedied by another pass with microsurfacing to cover it.

Post Production – June 18th

Comment was received from construction that Ramps 1 and 2 were not performing well. On Ramp 1, the photo below on the left, flushing was observed over the majority of the ramp in the wheelpaths. While no deformation or rutting in the wheelpaths was visible, it appeared that the course aggregate had been depressed and the fines were flushed to the surface. On Ramp 2, photo below on the right, the center left hand turn lane had severe flushing and also deformation/shoving of the microsurfacing material.

Photo 14 - Ramp 1 Flushing Distress

Photo 15 - Ramp 2 Flushing Distress

Construction had noted Ramps 1 and 2 were being used on a haul route for borrow material being transported to Anchorage International Airport for construction work. On Ramp 2 the damage occurred directly in front of a signalized intersection within a few days of application. It is likely the trucks coming to a stop and then accelerating into the turn onto International Airport Road that caused significant damage on the fresh microsurfacing, including flushing and material pickup.

It was observed the trucks returning to the pit from Anchorage International Airport used Ramp 1 onto Minnesota and then took Ramp 10 onto Raspberry and likely caused flushing damage to the recently placed microsurfacing on both of those ramps.

The other ramps were inspected, and some moderate flushing was observed on Ramps 5 and 13, with minor flushing on Ramps 11 and 16.

Post Production – August 10th through August 13th

Construction continued to review and monitor the ramp performance, and on August 10th determined that there had been sufficient flushing distress with loss of friction to warrant friction testing and potential removal. On August 12th a site visit was conducted with the Construction Project manager and Project Engineer to review the ramps proposed for removal.

The photo below is from August 13th where severe flushing and shoving occurred at the signalized intersection on Ramp 2. The resulting surface was not sticky and tracking was not observed at any locations, but there was a loss of friction and the fines were visible at the surface.

Photo 16 - Ramp 2 Flushing Distress

Ramps 1, 2 and 10 were a part of the haul route for QAP hauling borrow material to the airport, Ramp 5 was the ramp with the second highest AADT, being the exit ramp for traffic travelling from downtown Anchorage to the Anchorage International Airport and experiences heavy traffic loading.

Friction testing was performed on August 13th on the five ramps displaying the flushing/bleeding distress with loss of friction. Tests were performed on locations with flushing/bleeding, on non-distressed areas as a control for microsurfacing, and on hot mix pavement outside the application for a standard pavement control value. The result from the five distressed locations tested using a Dynamic Friction Tester (DFT) was:

Table 2 - Friction Testing Results

Ramp Number	Distressed Micro	Non-Distressed Micro	Hot Mix
1	0.31	0.54	0.54
2	0.28	0.45	0.47
5	0.28	0.47	0.48
10	0.35	0.53	0.55
13	0.45	0.52	0.57
Average:	0.33	0.50	0.52

While Ramp 13, the Dimond SB On Ramp, had a higher friction value in the distressed area than the other distressed ramps, there was visible flushing and it was decided to pursue removal of the portion of the ramp with visible flushing while performing the other repairs.

The final list of ramps determined to have sufficient loss of friction to warrant friction testing and removal were Ramps 1, 2, 5, 10 and 13. The area for 2020 removal due to a loss of friction from bleeding flushing/bleeding is 8,960 SY. This removal is anticipated to take place in September and be replaced with 1.5" of hot mix asphalt.

Recommendations from Construction

To be provided by construction by the end of the 2020 construction season and will be included in the 1st Year Monitoring Report.

Monitoring Plan

The three year post-construction monitoring plan consists of monitoring microsurfacing conditions in the following areas:

- Overall microsurfacing condition
    - Ramps will be visually inspected and photographed annually to document overall performance, including raveling and shoving
- Microsurfacing condition by rut depth, reflective cracking and roughness (IRI)
    - To be collected as part of the annual pavement management data collection
- Annual friction data collected by DFT to evaluate friction loss
- Performance of microsurfacing placed over existing pavement compared to that over new pavement
    - This will not be possible as locations placed over new pavement or pre-leveled locations are being removed due to bleeding/flushing failures in September 2020.

Observations and Results

The unexpected change in the crude source for the binder led to difficulties during the first day of production and a short delay while the additives were altered from lime to cement and aluminum sulfate and also required a new test strip and mix design be performed. This change was to increase the mix time to above 120 seconds and reduce the set time to allow traffic to return sooner.

The results from the new mix design indicate that the mix may have some long term moisture susceptibility as the wet track abrasion loss was above the specified limit on the six-day soak procedure (ISSA TB-100). The wet cohesion test (ISSA TB-139) was 18, just under the 20kg-cm minimum value at 60 minutes, indicating it would take over an hour for the mix to be able to withstand straight rolling traffic. The mix being a slow set system was understood, and it took approximately an hour and a half for the system to be rolled by the pneumatic rollers allowing it to then be opened to traffic.

The mix did pass the Excess Asphalt by Loaded Wheel Tester (ISSA TB-109) that is intended to establish maximum limits for asphalt contents to avoid asphalt flushing/bleeding under heavy traffic loads. It also passed the Lateral Displacement Test (ISAA TB-147) that measures the displacements characteristics of multilayered slurries under simulated rolling traffic compaction.

With the mix design passing both the Exess Asphalt and Lateral Displacement tests it is surprising there was a flushing failure in the field. It is possible that with the microsurfacing system being slow set, the trucks on the distressed ramps were able to cause the flushing damage prior to the system achieving its full strength. The lab tests were likely performed on oven cured samples that would have achieved higher strength than would have been seen in the field when the damage occurred.

The long term moisture susceptibility the ISSA test results indicate will be monitored during the three years of this project. See Appendix C for the mix design and materials testing results.

To understand the reason for the flushing failures truck counts and AADT data was pulled from the traffic server database. The table below displays 2019 data, and there appears to be a correlation between the high AADTs, truck counts and ramps with flushing failures, highlighted in red.

Table 3 - AADT and Truck Traffic

Ramp #	Name	AADT	Class 6+	Percentage (6+)
1	INTERNATIONAL AIRPORT EB - MINNESOTA SB RAMP	4,995	30	0.6
2	MINNESOTA NB - INTERNATIONAL AIRPORT RAMP	6,901	40	0.6
3	INTERNATIONAL AIRPORT EB - MINNESOTA NB LOOP	3,428	25	0.7
4	INTERNATIONAL AIRPORT - MINNESOTA NB RAMP	2,926	11	0.4
5	MINNESOTA SB - INTERNATIONAL AIRPORT WB WYE	7,100	37	0.3
6	MINNESOTA SB - INTERNATIONAL AIRPORT RAMP	5,852	24	0.6
7	INTERNATIONAL AIRPORT WB - MINNESOTA SB LOOP	1,401	9	0.6
8	RASPBERRY WB - MINNESOTA SB RAMP	1,020	10	1.0
9	RASPBERRY WB - MINNESOTA NB RAMP	1,441	14	1.0
10	MINNESOTA SB - RASPBERRY WB RAMP	5,862	65	1.1
11	RASPBERRY EB - MINNESOTA SB RAMP	2,902	29	1.0
12	MINNESOTA SB - STRAWBERRY RAMP	1,825	20	1.1
13	DIMOND - MINNESOTA SB RAMP	3,528	40	1.1
14	MINNESOTA SB - 100TH RAMP	2,576	18	0.7
15	100TH AVE - MINNESOTA SB RAMP	1,405	9	0.7
16	MINNESOTA NB - 100TH RAMP	3,668	23	0.6
17	100TH AVE - MINNESOTA NB RAMP	2,967	25	0.9

The emulsification of the PG 64-40E binder, using the Kraton modifier with a very high SBS polymer content (6% - 8%) maintained the original binder Jnr and Percent Recovery properties when the residual binder was tested according to AASHTO T-350 MSCR. This was considered critical to the success of the project as with the high residual binder content (10%) with the low end of the binder being soft at -37, the Jnr and recovery properties would be needed to resist plastic deformation from the traffic loading.

The ramp conditions will be assessed in October or November 2020 after studded tires are allowed but prior to typical snowfall, and in the spring of 2021 the ramp conditions will be re-assessed after one season of wear from studded tires and snowplows.