National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

MnROAD
Safer, Smarter, Sustainable Pavements Through Innovative Research

Pavement Preservation Group Study

Summary of Findings 2019

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BACKGROUND

The Pavement Preservation Group (PG) Study initiated in 2012 in an effort to provide agencies with better information regarding the life-extending benefit of various treatments. The research project involved the construction of full-scale test sections subjected to live traffic in different locations with the objective of studying field performance and obtaining life extending benefit curves as a function of climate, traffic volume and existing condition of the pavement.

The first test sections were constructed in 2012 on Lee Road 159, a two-lane low traffic volume county road in Auburn, Alabama. This road provides dead end access to a quarry and an asphalt plant, resulting in a high percentage of heavy loads (approximately 60%). The half-mile road segment was split into 25 100-foot long sections, of which 23 sections received a treatment or combination of treatments, and 2 were left as untreated control sections with varying amounts of cracking.

The study was expanded in the 2015 NCAT research cycle by placing an extended version of the pavement preservation treatments/combinations on a high traffic roadway in Alabama. A total of 34 sections were treated on a stretch of US-280 in Alabama. In this location, treatments were placed on the outside lane of the two-lane eastbound highway, and sections were 1/10 mile in length. Untreated control sections are also included to represent low and high levels of cracking, rutting, IRI and macrotexture.

In an effort to conduct research that is implementable under different climatic conditions, NCAT partnered with the Minnesota DOT's Road Research Facility (MnROAD) and constructed additional test sections in the summer of 2016. Two locations near Pease, Minnesota were selected to mirror the experimental plan already under way in Alabama. To study treatment performance under low traffic volume, 22 sections were treated on County State Aid Highway 8 (CSAH 8); while 21 sections were treated in a segment of the outside lane of the northbound US-169, a four-lane divided highway subjected to high traffic. Untreated sections are also included in both locations, and all sections have a length of 1/10 mile.

The year 2019 marked the beginning of Phase II of the PG Study, where NCAT and MnROAD will continue to monitor and analyze the performance of the sections under a new pooled fund sponsored by 21 state departments of transportation, the Federal Highway Administration, and FP^2, Inc. This document summarizes the findings and observations for the January 1 – December 31, 2019 period.

Treatments

The PG study was designed to include a wide variety of preservation treatments, ranging from crack sealing/filling to thin overlays, as well as combinations. In general, treatments can be grouped into the following categories: single or stand-alone treatments, combinations of surface treatments (including multi-layer treatments), thin overlays using various HMA mixture types, combinations of surface treatments and thin overlays, and cold recycling with a thin overlay wearing surface. Table 1 shows all the treatments considered in the study by location (North or South) and traffic level.

Table 1. Summary of Preservation Treatments Included in the Study

Treatment Category	Treatment/ Treatment Combination(s)	South		North	
		Low	High	Low	High
Single Treatments	Fog Seal	✓	✓	✓	✓
	Rejuvenating Fog Seal	✓	✓	✓	✓
	Crack Sealing	✓	✓	✓	✓
	Chip Seal	✓	✓	✓	✓
	Scrub Seal	✓	✓	✓	✓
	Chip Seal over Fiber Membrane	✓	✓	✓	✓
	Micro Surface	✓	✓	✓	
	Micro Surface with Fibers		✓		✓
	HiMA Micro Surface		✓		
Combination of Surface Treatments	Chip Seal with Crack Sealing	✓	✓	✓	✓
	Micro Surface with Crack Sealing	✓	✓	✓	✓
	Cape Seal (Micro on Chip Seal)	✓	✓	✓	✓
	Scrub Cape Seal (Micro on Scrub Seal)	✓	✓	✓	✓
	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	✓	✓	✓	✓
	Double Micro Surface	✓	✓	✓	✓
	Double Chip Seal	✓	✓	✓	✓
	Triple Chip Seal	✓	✓	✓	✓
HMA Thin Overlays	Virgin Thinlay	✓	✓	✓	✓
	Asphalt Binder Replacement (ABR) Thinlay		✓	✓	✓
	OGFC w/Trackless Tack		✓		
	OGFC w/ PG 67-22 Tack		✓		
	OGFC w/UltraFuse		✓		
	OGFC w/eTac		✓		
	OGFC w/Spray paver		✓		
	Ultra Thin Bonded Surface	✓	✓	✓	✓
	50% RAP Thinlay	✓			
	5% PC-RAS Thinlay	✓			
	HiMA Thinlay	✓			✓
Combination with HMA Thin Overlays	Micro Surface on Thinlay		✓		
	Thinlay Scrub Cape (HMA on Scrub Seal)		✓	✓	
	Thinlay Fiber Cape (HMA on Chip Seal over Fiber Membrane)	✓	✓	✓	✓
	Thinlay Cape (HMA on Chip Seal)		✓	✓	✓
Cold Recycling + Thin HMA Overlay	Thinlay on Foamed CCPR	✓	✓		✓
	Thinlay on Emulsion CCPR		✓		✓
	Thinlay on Foamed CIR		✓		✓
	Thinlay on Emulsion CIR		✓		✓
	Thinlay on Foamed SFDR				✓
	Thinlay on Emulsion SFDR				✓

Condition Assessment

Condition data are collected periodically to evaluate surface distress, ride quality, friction, and structural integrity of the pavements. Given that the PG study is sponsored primarily by state DOTs, it is important that pavement condition be evaluated in a way that is consistent among agencies. With that in mind, this document focuses on the MAP-21 performance indicators

established by the Federal Highway Administration. Table 2 shows the condition rating for each of the performance measures used for asphalt pavements.

Table 2. Condition ratings for MAP-21 Performance Measures

Condition Rating	% of Area Cracked	Rutting, in	IRI, in/mi
Good	< 5%	< 0.20	< 95
Fair	5 – 20%	0.20 – 0.40	95 – 170
Poor	> 20%	> 0.40	> 170

2019 PERFORMANCE MEASUREMENTS

The following sections show the first and last performance measurements for 2019 to illustrate how the different indicators varied over the year.

Cracking

Historically, cracking has been the indicator that exhibits the most variation in the test sections. Tables 3 through 6 show the cracking results in all four locations. Cells are color coded to represent the condition category (Green = Good, Yellow = Fair, Red = Poor).

Table 3. Cracking Performance on Lee Road 159

Section No.	Description	Cracking, % Area	
		Start 2019	End 2019
L1	Rejuvenating Fog Seal	30.2	32.9
L2	Chip Seal over Fiber Membrane	16.0	16.8
L3	Control	28.1	28.2
L4	Control	59.4	60.6
L5	Crack Sealing	42.5	43.5
L6	Chip Seal	13.9	16.2
L7	Chip Seal with Crack Sealing	10.2	10.4
L8	Triple Chip Seal	4.5	5.2
L9	Double Chip Seal	6.7	7.2
L10	Cape Seal (Micro on Chip Seal)	4.4	4.5
L11	Micro Surface	28.0	31.1
L12	Micro Surface with Crack Sealing	28.1	32.3
L13	Double Micro Surface	5.2	5.7
L14	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	1.8	1.9
L15	Scrub Cape Seal (Micro on Scrub Seal)	3.2	3.2
L16	Scrub Seal	3.3	3.5
L17	Chip Seal over Fiber Membrane	9.5	10.3
L18	HMA Thinlay on Chip Seal over Fiber Membrane	2.4	2.5
L19	Virgin Thinlay (PG 67-22)	4.0	4.4
L20	Thinlay on Foamed CCPR	3.7	3.7
L21	Virgin Thinlay (PG 76-22)	4.2	5.0
L22*	Ultra Thin Bonded Surface	4.9	9.2
L23	50% RAP Thinlay	16.8	20.9
L24	5% PC-RAS Thinlay	14.6	21.5
L25	HiMA Thinlay	1.8	3.0

*Inbound lane only. Outbound lane was milled and inlaid with ABR thinlay in 2018.

Table 4. Cracking Performance on US-280

Section No.*	Description	Cracking, % Area	
		Start 2019	End 2019
U6	Virgin Thinlay	0.1	0.3
U7	Double Micro Surface (Limestone)	3.2	3.9
U8	Crack Sealing	0.7	1.0
U9	Micro Surface with Fibers	5.8	6.8
U10	HiMA Micro Surface	3.6	4.5
U11	Rejuvenating Fog Seal	4.7	5.6
U12	Fog Seal	3.2	3.7
U13	Control	1.1	2.3
U14	Chip Seal with Crack Sealing	0.3	0.4
U15	Scrub Cape Seal (Micro on Scrub Seal)	2.5	2.9
U16	Chip Seal	4.1	4.6
U17	Control	2.1	3.4
U18	Micro Surface	8.5	10.2
U19	Control	7.4	7.9
U20	Control	4.7	6.6
U21	Scrub Cape Seal (Micro on Scrub Seal)	8.3	9.8
U22	Micro Surface with Crack Sealing	9.4	11.0
U23	Cape Seal (Micro on Chip Seal)	10.3	12.1
U24	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	6.7	7.2
U25	Chip Seal over Fiber Membrane	0.2	0.4
U26	Triple Chip Seal	0.0	0.0
U27	Double Chip Seal	0.0	0.0
U28	Double Micro Surface (Sandstone)	0.1	0.2
U29	Control	0.0	0.3
U30	OGFC w/Spray Paver	0.1	0.4
U31	OGFC w/Trackless Tack	0.4	0.6
U32	OGFC w/ PG 67-22 Tack	1.0	1.3
U33	OGFC w/UltraFuse	0.0	0.2
U34	OGFC w/eTac	0.3	0.3
U35	HMA Thinlay on Scrub Seal	5.3	6.4
U36	HMA Thinlay on Chip Seal over Fiber Membrane	8.9	10.3
U37	HMA Thinlay on Chip Seal	8.9	9.7
U38	Micro Surface on HMA Thinlay	1.0	1.1
U39	Asphalt Binder Replacement (ABR) Thinlay	5.9	6.6
U40	Thinlay on Foamed CCPR	0.1	1.1
U41	Thinlay on Emulsion CCPR	0.0	0.0
U42	Untreated – Traffic Loop	0.2	0.2
U43	Thinlay on Emulsion CIR	0.1	0.1
U44	Thinlay on Foamed CIR	0.0	0.0
U45	Ultra Thin Bonded Surface	0.0	0.0
U46	Control	0.1	0.4

* Sections U1 – U5 are “Unassigned” and may be available for future treatments.

Table 5. Cracking Performance on CSAH 8

Section No.	Description	Cracking, % Area	
		Start 2019	End 2019
8001	Crack Sealing / Transverse Mastic	5.7	5.7
8002	Chip Seal with Crack Sealing / Transverse Mastic	7.7	7.7
8003	Chip Seal	4.5	4.5
8004	Cape Seal (Micro on Chip Seal)	2.3	2.3
8005	Double Chip Seal	1.6	1.8
8006	Triple Chip Seal	2.0	2.0
8007	Chip Seal over Fiber Membrane	2.5	2.5
8008	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	1.8	2.2
8009	Scrub Cape Seal (Micro on Scrub Seal)	1.8	1.8
8010	Scrub Seal	4.1	4.1
8011	Micro Surface with Crack Sealing / Transverse Mastic	2.2	2.2
8012	Micro Surface	1.7	2.1
8013	Double Micro Surface	2.5	2.5
8014	Fog Seal with Black Diamond Dust	2.0	2.5
8015	Rejuvenating Fog Seal with Black Diamond Dust	4.9	9.1
8016	HMA Thinlay on Chip Seal over Fiber Membrane	1.1	1.9
8017	HMA Thinlay on Scrub Seal	1.1	1.1
8018	HMA Thinlay on Chip Seal	1.8	2.0
8019	Control	5.0	5.4
8020	Control	3.5	3.5
8021	Control	5.5	6.8
8022	Control	2.7	2.7
8023	Virgin Thinlay	1.9	1.9
8024	Asphalt Binder Replacement (ABR) Thinlay	1.3	1.5
8025	Control	3.2	3.2
8026	Control	2.2	2.2
8027	Control	2.7	2.7
8028	Ultra Thin Bonded Surface	1.8	1.8
8029	Asphalt Binder Replacement (ABR) Thinlay with Rejuvenator	1.4	1.4
8030	Control	3.5	2.7

Table 6. Cracking Performance on US-169

Section No.	Description	Cracking, % Area	
		Start 2019	End 2019
169000	Control	11.6	13.3
169001	Crack Sealing / Transverse Mastic	6.4	6.4
169002	Chip Seal with Crack Sealing / Transverse Mastic	5.4	5.4
169003	Chip Seal	9.4	10.9
169004	Double Chip Seal	2.6	3.7
169005	Triple Chip Seal	2.9	3.6
169006	Cape Seal (Micro on Chip Seal)	0.7	1.3
169007	Micro Surface with Crack Sealing / Transverse Mastic	0.5	1.2
169008	Micro Surface with Fibers	0.5	0.6
169009	Double Micro Surface	0.3	0.5
169010	Chip Seal over Fiber Membrane	2.4	2.4
169011	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	0.7	1.2
169012	Scrub Cape Seal (Micro on Scrub Seal)	0.2	0.8
169013	Scrub Seal	4.0	4.0
169014	Control	10.9	10.9
169015	Control	9.6	15.1
169016	Control	9.3	13.4
169017	Rejuvenating Fog Seal	4.0	7.9
169018	Control	6.2	8.2
169019	Fog Seal	7.0	10.4
169020	Control	4.9	6.8
169021	Control	2.5	4.3
169022	Asphalt Binder Replacement (ABR) Thinlay with Rejuvenator	1.4	1.4
169023	Virgin Thinlay	0.1	0.1
169024	Ultra Thin Bonded Surface	0.2	1.7
169025	HiMA Thinlay	0.1	0.4
169026	Asphalt Binder Replacement (ABR) Thinlay	0.1	0.5
169027	HMA Thinlay on Chip Seal	0.3	0.4
169028	Control	4.1	6.3

Figure 1 shows the number of sections in each condition category at the start and end of the year for all four locations. On Lee Road 159, where test sections have been in service for a longer period (over seven years), sections are distributed more evenly among the three condition categories. Furthermore, this is the only location with sections that have reached the "poor" category, which would be expected for some of the treatments within this period. In the remaining three test locations, the majority of sections remain in the "good" condition category. However, there was a reduction in the number of sections in "good" condition in all cases, meaning some of the treatments migrated to the "fair" condition over the course of the year.

Figure 1. Number of Sections by Condition Category (Cracking)

Rutting

In general, rutting performance has been good for the majority of test sections and has shown very little change over time. Tables 7 through 10 show the rutting results in all four locations. Rutting measurements are not as straight forward as cracking and may exhibit seasonal variability in addition to testing variability. Therefore, it is not unusual to see instances where rutting decreases from one test date to the next. However, these variations are small and not statistically significant.

Table 7. Rutting Performance on Lee Road 159

Section No.	Description	Avg. Rut Depth, mm	
		Start 2019	End 2019
L1	Rejuvenating Fog Seal	3.8	8.1
L2	Chip Seal over Fiber Membrane	3.1	5.5
L3	Control	3.0	2.7
L4	Control	3.4	2.9
L5	Crack Sealing	2.8	2.7
L6	Chip Seal	2.0	2.0
L7	Chip Seal with Crack Sealing	2.6	2.5
L8	Triple Chip Seal	2.4	2.6
L9	Double Chip Seal	2.9	2.9
L10	Cape Seal (Micro on Chip Seal)	3.0	2.7
L11	Micro Surface	3.9	3.2
L12	Micro Surface with Crack Sealing	3.5	2.7
L13	Double Micro Surface	4.8	3.3
L14	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	4.4	3.6
L15	Scrub Cape Seal (Micro on Scrub Seal)	3.4	2.8
L16	Scrub Seal	3.7	3.2
L17	Chip Seal over Fiber Membrane	3.5	3.2
L18	HMA Thinlay on Chip Seal over Fiber Membrane	1.3	1.3
L19	Virgin Thinlay (PG 67-22)	1.4	1.8
L20	Thinlay on Foamed CCPR	2.8	2.6
L21	Virgin Thinlay (PG 76-22)	2.1	2.3
L22*	Ultra Thin Bonded Surface	3.0	3.0
L23	50% RAP Thinlay	1.9	2.1
L24	5% PC-RAS Thinlay	2.1	2.3
L25	HiMA Thinlay	2.2	2.5

*Inbound lane only. Outbound lane was milled and inlaid with ABR thinlay in 2018.

Table 8. Rutting Performance on US-280

Section No.*	Description	Avg. Rut Depth, mm	
		Start 2019	End 2019
U6	Virgin Thinlay	1.1	1.4
U7	Double Micro Surface (Limestone)	3.7	5.6
U8	Crack Sealing	5.2	8.2
U9	Micro Surface with Fibers	3.4	4.6
U10	HiMA Micro Surface	3.6	4.8
U11	Rejuvenating Fog Seal	4.4	5.0
U12	Fog Seal	4.5	5.4
U13	Control	6.1	7.4
U14	Chip Seal with Crack Sealing	5.2	6.3
U15	Scrub Cape Seal (Micro on Scrub Seal)	2.4	3.3
U16	Chip Seal	3.8	4.6
U17	Control	3.1	3.8
U18	Micro Surface	3.1	3.7
U19	Control	5.7	6.9
U20	Control	4.7	6.7
U21	Scrub Cape Seal (Micro on Scrub Seal)	3.9	5.4
U22	Micro Surface with Crack Sealing	3.8	4.0
U23	Cape Seal (Micro on Chip Seal)	4.2	4.8
U24	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	2.8	3.8
U25	Chip Seal over Fiber Membrane	3.0	4.1
U26	Triple Chip Seal	4.3	4.8
U27	Double Chip Seal	3.1	3.6
U28	Double Micro Surface (Sandstone)	2.4	2.7
U29	Control	2.8	4.1
U30	OGFC w/Spray paver	2.3	2.9
U31	OGFC w/Trackless Tack	2.1	3.4
U32	OGFC w/ PG 67-22 Tack	2.6	3.4
U33	OGFC w/UltraFuse	2.4	3.8
U34	OGFC w/eTac	2.4	3.2
U35	HMA Thinlay on Scrub Seal	1.5	3.1
U36	HMA Thinlay on Chip Seal over Fiber Membrane	1.5	2.7
U37	HMA Thinlay on Chip Seal	1.6	2.7
U38	Micro Surface on HMA Thinlay	1.4	1.8
U39	Asphalt Binder Replacement (ABR) Thinlay	1.4	2.2
U40	Thinlay on Foamed CCPR	3.4	3.6
U41	Thinlay on Emulsion CCPR	2.0	3.0
U42	Untreated – Traffic Loop	4.5	4.9
U43	Thinlay on Emulsion CIR	3.9	4.9
U44	Thinlay on Foamed CIR	4.5	4.8
U45	Ultra Thin Bonded Surface	1.8	2.5
U46	Control	4.7	5.1

*Sections U1 – U5 are “Unassigned” and may be available for future treatments.

Table 9. Rutting Performance on CSAH 8

Section No.	Description	Avg. Rut Depth, mm	
		Start 2019	End 2019
8001	Crack Sealing / Transverse Mastic	3.0	3.0
8002	Chip Seal with Crack Sealing / Transverse Mastic	1.7	2.0
8003	Chip Seal	1.8	2.1
8004	Cape Seal (Micro on Chip Seal)	1.5	1.7
8005	Double Chip Seal	2.0	2.3
8006	Triple Chip Seal	1.3	1.5
8007	Chip Seal over Fiber Membrane	1.6	2.0
8008	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	0.9	1.0
8009	Scrub Cape Seal (Micro on Scrub Seal)	1.4	1.8
8010	Scrub Seal	1.9	2.3
8011	Micro Surface with Crack Sealing / Transverse Mastic	2.6	3.2
8012	Micro Surface	2.5	2.7
8013	Double Micro Surface	2.6	3.0
8014	Fog Seal with Black Diamond Dust	3.1	3.5
8015	Rejuvenating Fog Seal with Black Diamond Dust	5.3	5.9
8016	HMA Thinlay on Chip Seal over Fiber Membrane	1.5	1.7
8017	HMA Thinlay on Scrub Seal	1.3	1.7
8018	HMA Thinlay on Chip Seal	1.4	1.7
8019	Control	2.9	3.3
8020	Control	1.8	2.2
8021	Control	3.2	3.4
8022	Control	2.4	2.8
8023	Virgin Thinlay	1.4	1.8
8024	Asphalt Binder Replacement (ABR) Thinlay	1.3	1.7
8025	Control	1.2	1.5
8026	Control	2.0	2.4
8027	Control	2.4	2.7
8028	Ultra Thin Bonded Surface	1.8	2.1
8029	Asphalt Binder Replacement (ABR) Thinlay with Rejuvenator	1.0	1.5
8030	Control	1.6	2.2

Table 10. Rutting Performance on US-169

Section No.	Description	Cracking, % area	
		Start 2019	End 2019
169000	Control	3.7	3.3
169001	Crack Sealing / Transverse Mastic	3.8	3.8
169002	Chip Seal with Crack Sealing / Transverse Mastic	2.9	3.0
169003	Chip Seal	3.5	3.6
169004	Double Chip Seal	1.3	1.6
169005	Triple Chip Seal	1.6	2.2
169006	Cape Seal (Micro on Chip Seal)	1.9	2.0
169007	Micro Surface with Crack Sealing / Transverse Mastic	2.8	1.9
169008	Micro Surface with Fibers	2.0	2.1
169009	Double Micro Surface	2.8	2.9
169010	Chip Seal over Fiber Membrane	2.5	2.0
169011	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	2.0	1.6
169012	Scrub Cape Seal (Micro on Scrub Seal)	1.6	1.4
169013	Scrub Seal	1.5	1.2
169014	Control	4.4	4.4
169015	Control	5.8	6.1
169016	Control	4.6	4.5
169017	Rejuvenating Fog Seal	2.4	2.7
169018	Control	3.3	3.5
169019	Fog Seal	4.2	4.3
169020	Control	5.6	5.2
169021	Control	4.3	4.0
169022	Asphalt Binder Replacement (ABR) Thinlay with Rejuvenator	1.6	1.8
169023	Virgin Thinlay	1.7	1.7
169024	Ultra Thin Bonded Surface	2.3	2.4
169025	HiMA Thinlay	2.2	2.4
169026	Asphalt Binder Replacement (ABR) Thinlay	2.4	2.7
169027	HMA Thinlay on Chip Seal	2.5	2.0
169028	Control	4.0	3.3

Figure 2 shows the number of sections in each condition category at the start and end of the year for all four locations. It can be observed that only in the southern locations (Lee Road 159 and US-280), there were sections the deteriorated enough to fall under a different condition category. The northern sections (CSAH 8 and US-169) maintained their condition categories throughout the year.

Figure 2. Number of Sections by Condition Category (Rutting)

Roughness

Similar to rutting, IRI data can either increase or decrease over time due to testing variability, but roughness has remained relatively constant through the year on average. As shown in Figures 11 through 14, roughness does not appear to be an issue in most cases. The exception is CSAH 8, where the majority of test sections are either in the "fair" or "poor" condition category. The high roughness results are related to high severity thermal cracks found in this roadway.

Table 11. Roughness Performance on Lee Road 159

Section No.	Description	IRI, in/mi	
		Start 2019	End 2019
L1	Rejuvenating Fog Seal	58.1	56.5
L2	Chip Seal over Fiber Membrane	76.6	66.4
L3	Control	66.8	66.7
L4	Control	62.6	62.6
L5	Crack Sealing	80.9	82.2
L6	Chip Seal	67.2	66.9
L7	Chip Seal with Crack Sealing	78.6	81.2
L8	Triple Chip Seal	89.4	89.6
L9	Double Chip Seal	75.8	76.7
L10	Cape Seal (Micro on Chip Seal)	75.5	77.0
L11	Micro Surface	76.5	76.8
L12	Micro Surface with Crack Sealing	70.5	72.4
L13	Double Micro Surface	82.4	86.7
L14	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	64.8	66.8
L15	Scrub Cape Seal (Micro on Scrub Seal)	57.3	56.1
L16	Scrub Seal	73.1	70.7
L17	Chip Seal over Fiber Membrane	89.3	93.7
L18	HMA Thinlay on Chip Seal over Fiber Membrane	66.5	62.7
L19	Virgin Thinlay (PG 67-22)	60.3	69.5
L20	Thinlay on Foamed CCPR	123.9	126.1
L21	Virgin Thinlay (PG 76-22)	87.8	93.9
L22*	Ultra Thin Bonded Surface	112.0	110.4
L23	50% RAP Thinlay	87.3	89.3
L24	5% PC-RAS Thinlay	69.5	76.7
L25	HiMA Thinlay	147.6	165.5

*Inbound lane only. Outbound lane was milled and inlaid with ABR thinlay in 2018.

Table 12. Roughness Performance on US-280

Section No.*	Description	IRI, in/mi	
		Start 2019	End 2019
U6	Virgin Thinlay	55.7	55.7
U7	Double Micro Surface (Limestone)	75.8	71.5
U8	Crack Sealing	62.1	53.2
U9	Micro Surface with Fibers	53.0	55.6
U10	HiMA Micro Surface	49.6	49.2
U11	Rejuvenating Fog Seal	46.1	50.9
U12	Fog Seal	51.8	54.1
U13	Control	62.4	55.4
U14	Chip Seal with Crack Sealing	66.6	63.3
U15	Scrub Cape Seal (Micro on Scrub Seal)	72.1	70.3
U16	Chip Seal	80.8	77.9
U17	Control	54.9	53.8
U18	Micro Surface	71.8	69.4
U19	Control	60.2	59.4
U20	Control	52.7	52.5
U21	Scrub Cape Seal (Micro on Scrub Seal)	66.6	66.3
U22	Micro Surface with Crack Sealing	61.4	58.7
U23	Cape Seal (Micro on Chip Seal)	46.9	47.3
U24	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	55.1	53.9
U25	Chip Seal over Fiber Membrane	56.7	55.5
U26	Triple Chip Seal	52.2	51.8
U27	Double Chip Seal	51.4	47.6
U28	Double Micro Surface (Sandstone)	48.3	48.4
U29	Control	46.9	46.8
U30	OGFC w/Spray paver	54.6	58.1
U31	OGFC w/Trackless Tack	54.7	57.6
U32	OGFC w/ PG 67-22 Tack	46.7	48.7
U33	OGFC w/UltraFuse	43.9	42.0
U34	OGFC w/eTac	59.7	56.6
U35	HMA Thinlay on Scrub Seal	54.5	55.0
U36	HMA Thinlay on Chip Seal over Fiber Membrane	40.5	40.0
U37	HMA Thinlay on Chip Seal	60.1	59.3
U38	Micro Surface on HMA Thinlay	57.3	57.3
U39	Asphalt Binder Replacement (ABR) Thinlay	48.1	50.7
U40	Thinlay on Foamed CCPR	74.7	74.8
U41	Thinlay on Emulsion CCPR	66.4	73.2
U42	Untreated – Traffic Loop	56.9	56.5
U43	Thinlay on Emulsion CIR	87.4	87.9
U44	Thinlay on Foamed CIR	65.7	63.0
U45	Ultra Thin Bonded Surface	52.5	51.7
U46	Control	32.1	31.9

* Sections U1 – U5 are “Unassigned” and may be available for future treatments.

Table 13. Roughness Performance on CSAH 8

Section No.	Description	IRI, in/mi	
		Start 2019	End 2019
8001	Crack Sealing / Transverse Mastic	126.3	142.3
8002	Chip Seal with Crack Sealing / Transverse Mastic	120.7	117.3
8003	Chip Seal	137.0	129.9
8004	Cape Seal (Micro on Chip Seal)	121.1	114.5
8005	Double Chip Seal	131.7	117.8
8006	Triple Chip Seal	116.8	110.7
8007	Chip Seal over Fiber Membrane	127.8	119.9
8008	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	88.9	91.4
8009	Scrub Cape Seal (Micro on Scrub Seal)	92.0	89.5
8010	Scrub Seal	106.8	101.9
8011	Micro Surface with Crack Sealing / Transverse Mastic	118.8	114.0
8012	Micro Surface	128.8	113.7
8013	Double Micro Surface	135.9	123.2
8014	Fog Seal with Black Diamond Dust	174.9	155.5
8015	Rejuvenating Fog Seal with Black Diamond Dust	236.0	222.4
8016	HMA Thinlay on Chip Seal over Fiber Membrane	116.3	124.6
8017	HMA Thinlay on Scrub Seal	87.0	90.6
8018	HMA Thinlay on Chip Seal	108.3	95.2
8019	Control	127.4	124.4
8020	Control	112.3	108.8
8021	Control	159.1	148.5
8022	Control	135.0	119.1
8023	Virgin Thinlay	51.6	49.8
8024	Asphalt Binder Replacement (ABR) Thinlay	50.0	44.0
8025	Control	162.5	152.8
8026	Control	119.9	103.5
8027	Control	165.5	140.8
8028	Ultra Thin Bonded Surface	95.6	81.4
8029	Asphalt Binder Replacement (ABR) Thinlay with Rejuvenator	86.6	83.5
8030	Control	116.8	109.3

Table 14. Roughness Performance on US-169

Section No.	Description	IRI, in/mi	
		Start 2019	End 2019
169000	Control	103.3	104.0
169001	Crack Sealing / Transverse Mastic	89.7	89.3
169002	Chip Seal with Crack Sealing / Transverse Mastic	80.0	85.1
169003	Chip Seal	97.0	95.1
169004	Double Chip Seal	94.0	87.9
169005	Triple Chip Seal	93.9	87.9
169006	Cape Seal (Micro on Chip Seal)	88.2	79.0
169007	Micro Surface with Crack Sealing / Transverse Mastic	65.5	71.4
169008	Micro Surface with Fibers	68.3	61.3
169009	Double Micro Surface	78.2	74.8
169010	Chip Seal over Fiber Membrane	90.3	85.8
169011	Fiber Cape Seal (Micro on Chip Seal over Fiber Membrane)	76.2	78.9
169012	Scrub Cape Seal (Micro on Scrub Seal)	75.8	71.9
169013	Scrub Seal	83.2	77.9
169014	Control	87.3	78.4
169015	Control	104.4	102.3
169016	Control	81.7	80.4
169017	Rejuvenating Fog Seal	83.6	82.7
169018	Control	95.2	84.6
169019	Fog Seal	72.7	71.0
169020	Control	76.9	75.6
169021	Control	98.6	93.6
169022	Asphalt Binder Replacement (ABR) Thinlay with Rejuvenator	39.5	44.5
169023	Virgin Thinlay	35.1	32.8
169024	Ultra Thin Bonded Surface	39.1	35.3
169025	HiMA Thinlay	65.1	72.0
169026	Asphalt Binder Replacement (ABR) Thinlay	73.0	65.5
169027	HMA Thinlay on Chip Seal	84.8	58.9
169028	Control	78.3	90.0

Figure 3 shows the number of sections in each condition category at the start and end of the year for all four locations. Contrary to the rutting results, there was no change in the general condition of the southern locations. Few sections in the northern sections experienced a reduction in IRI, which caused them to change condition categories. Since IRI can fluctuate, this should not be interpreted as an improvement; instead, such changes are a result of the IRI measurements being close to the threshold values that define the condition categories. Overall, roughness is higher in the northern sections even though they have been in service for a shorter amount of time.

Figure 3. Number of Sections by Condition Category (IRI)

OTHER ACTIVITIES COMPLETED IN 2019

During Phase I of the PG Study, several test sections were constructed in 2015using cold recycle technology (cold in-place recycling and cold central plant recycling) in Alabama but were not included in the layout of test sections located in Minnesota. To study the performance of these types of treatments in different climates, the NCAT-MnROAD partnership completed the construction of new test sections in Minnesota in August 2019. The new test sections were constructed on a one-mile long segment on 70th Street in the cities of Albertville and Otsego, located approximately 1 mile from MnROAD.

The selected test location was a heavily distressed two-lane road with an annual average daily traffic (AADT) of approximately 2,300 vehicles per day. To capture a variety of treatment options, the length of the project was divided into eight sections, which included stabilized full-depth reclamation (SFDR), cold in-place recycling (CIR), cold central plant recycling (CCPR), and conventional mill and inlay. Each of the recycling techniques included engineered emulsion and

foamed asphalt options, as shown in Figure 4. Due to time and logistic constraints, the focus of the project was on the eastbound lane. However, some of the treatments were also placed on the westbound lane, and the entire length of the project was surfaced with a 1-inch thinlay.

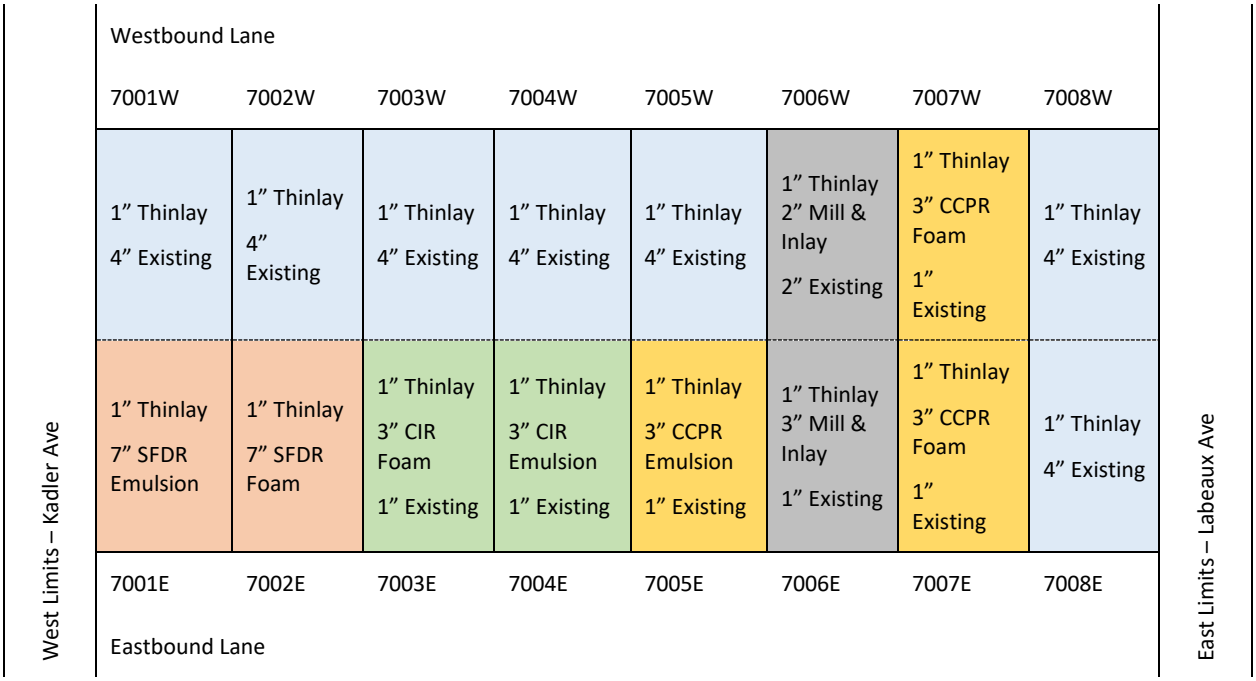

Figure 4. Test Site Layout on 70th Street

Because the sections have only been in place for a short amount of time and MnROAD's data collection schedule is interrupted during the winter months, a condition assessment of these sections is not currently available. The sections will continue to be monitored under the PG Study and findings will be reported in future documents.

SUMMARY OF FINDINGS

The PG Study is a long-term research effort that aims at quantifying the life-extending benefit of various pavement preservation treatments. Phase II is being carried out to obtain more field performance data necessary to achieve this objective. Although the study is ongoing, the following observations were obtained during 2019:

- Of the three main performance indicators (cracking, rutting and IRI), cracking continues to exhibit the most change over time. As expected, the amount of cracking is higher for sections that have been in service for a longer period, and particularly for some of the lighter treatments.
- Rutting and IRI remain relatively constant over time with some minor fluctuations resulting from testing and seasonal variability. At this point, no clear trends can be observed for these parameters.
- In general, rut depths are low, with most test sections under 5 mm. The southern high-traffic location (US-280) had higher rutting values and the most sections deteriorating to the

next condition category. This is expected due to the combination of a wet, no-freeze climate and higher traffic volume conditions.

- Roughness is higher on the northern sections, even though they have been in service for a shorter amount of time. The sections are subjected to an extreme wet, freeze climate, which results in high severity thermal cracking, which affects ride quality. The roughness on the low traffic location (CSAH 8) has been particularly affected by this type of cracking.
- The number of sections that have reached the “poor” condition category in any of the performance indicators is limited. Data collection efforts continue to gather the information needed to fulfill the objective of the study.