MnROAD / NCAT Pavement Preservation
Summary of Delta-S Experiment

Date	10/5/2021
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Pavement Preservation Treatments: Background

In 2015 the Minnesota Department of Transportation's Road Research facility (MnROAD) partnered with the National Center for Asphalt Technology (NCAT) to research two important national issues:

- Develop a National Pavement Preservation research effort to determine the life extending benefit curves of a number of different pavement preservation techniques constructed in both Alabama and Minnesota.
- Develop and implement asphalt performance tests to predict cracking for common distress found in North America.

In 2015 and 2016 NCAT and MnROAD installed test sections to support this effort. Visit http://www.dot.state.mn.us/mnroad/ncatpartnership/pavementpreservation/Cell%20Map%20Pavement%20Preservation%20March%202018.pdf for a map of the Minnesota sections.

Minnesota is the Lead State for Phase II of the pooled fund that supports this effort. Currently approximately 20 states are sponsoring these projects. The Foundation for Pavement Preservation and the National Center for Pavement Preservation are also active members. More pooled fund details are available at http://www.pooledfund.org/Details/Study/496 and http://www.dot.state.mn.us/mnroad/ncatpartnership/pavementpreservation/index.html.

Minnesota's Pavement Preservation Treatments: Delta-S Modification

In 2016 a total of 60 pavement preservation test sections (31 low traffic volume and 29 high volume) were installed in Mille Lacs County, Minnesota as part of a MnDOT/NCAT research partnership. Thinlay sections were constructed in August 2016. Section lengths were 0.1 mile and the depth of mill and overlay treatment was 0.75 in.

- Low Volume Location: CSAH 8 westbound – Traffic: 710 AADT (2014)
- High Volume Location: US 169 northbound – Traffic: 16,500 AADT (2016)

One test section on each road received a hot mix asphalt thinlay treatment modified with Delta-S. The roads also received thinlay sections constructed using nonmodified hot mix.

- Low Volume Location: **cell 8029 (delta-s), cell 8024 (no delta-s)**
  - Control: cells 8019-8022, 8025-8027, 8030, 8031
- High Volume Location: **cell 169022 (delta-s), cell 169026 (no delta-s)**
  - Control: cells 169000, 169014-169016, 169018, 169020, 169021, 169028

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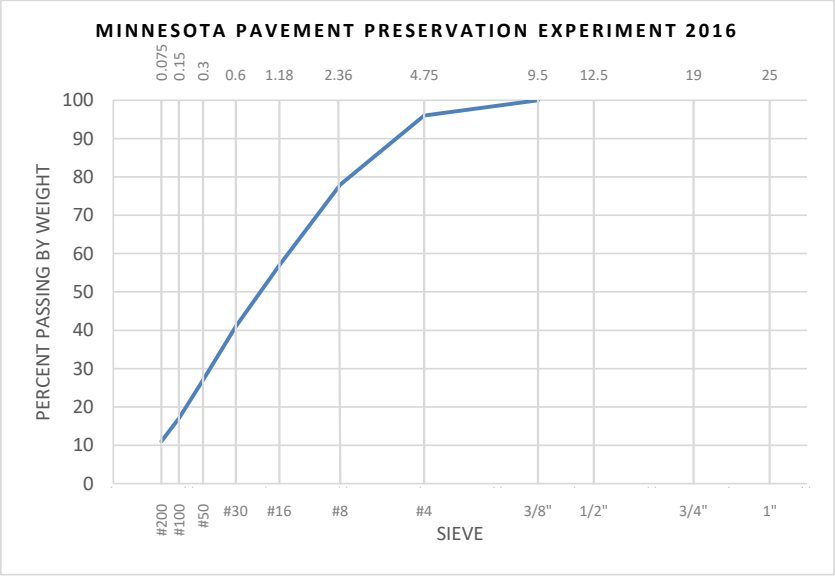
Mixture Information

A PG 64-34 asphalt binder was used for all of the cells. Delta-S was added to the mixture along with the asphalt binder at a rate of 28 ounces per ton of HMA.

Mixtures were designed at 75 gyrations to 4.0 percent air voids and a VMA of 14.0 percent. The design incorporated 5.0 percent new binder for a total binder content 6.4 percent. The asphalt film thickness of the design was calculated as 8.0 microns. Mixture unit weight at design conditions was 148.1 lb/cu ft.

The aggregate blend included Kingsway Screened Man Sand, Martin Marietta Washed Sand, Kingsway Pit Man Sand, Manufacture Waste Scrap Shingles, and Vonco Screened Fine RAP. The RAP proportion was 12%, and MWSS was 3% by weight of aggregate.

Sieve Size	Composite Formula
3/8" (9.5 mm)	100
#4 (4.75 mm)	96
#8 (2.36 mm)	78
#16 (1.18 mm)	57
#30 (0.6 mm)	41
#50 (0.3 mm)	27
#100 (0.15 mm)	17
#200 (0.075 mm)	11.0



4.75mm aggregate gradation used for Minnesota Thinlay mixtures with and without Delta-S.

General Notes: Construction equipment included a tack distributor and mixture transfer vehicle. The paving contractor was East Alabama Paving.

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Performance Observations

Sections with Delta-S

Mill and Delta-S Thinlay on County Road - Low Volume Cell 8029						
Date	**IRI in/mi**	**Locked Wheel Friction FN_{40}**	**Fatigue**	**Raveling**	**# Transverse Cracks**	**Reflected Cracks**
2016, Untreated	119.6	Not measured, Control Cell 8030 = 51.0 at time of 2016 treatments	NA	NA	NA	NA
2016, Treated	41.2	51.3	0	0	0	0%
April-May 2017, Treated	43.5	55.8	0	0	7	90%
September 2017, Treated	44.6	54.7	0	0	7	90%
May 2018, Treated	56.9	55.8	0	0	8	100%
May 2019, Treated	77.1	57.2	0	0	9	100%
June-August 2020, Treated	99.5	59.9	0	0	11	100%
May 2021, Treated	119.5	58.9	0	0	12	100%
Mill and Delta-S Thinlay on US Highway - High Volume Cell 169022						
Date	**IRI in/mi**	**Locked Wheel Friction FN_{40}**	**Fatigue**	**Raveling**	**# Transverse Cracks**	**Reflected Cracks**
2016, Untreated	81.1	46.7	NA	NA	NA	NA
2016, Treated	44.0	48.5	0	0	0	0%
July 2017, Treated	41.0	51.1	0	0	21	70%
May 2018, Treated	50.4	51.2	0	0	24	80%
May 2019, Treated	41.2	51.9	0	0	26	49%*
June-August 2020, Treated	41.4	57.8	0	0	26	59%
May 2021, Treated	47.9	53.6	0	0	37	72%
(*) 2019 Decrease in Delta-S Reflected Cracks (driving lane) was not due to patching or healing. Reduction resulted after additional working transverse cracks were identified in the Passing Lane (PL micro surfacing placed 2016).						

Cell 8029 Thinlay with Delta-S: As constructed in 2016 (left) and inspected 4-28-21 (right).

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Cell 169022 Thinlay with Delta-S: As constructed in 2016 (left) and inspected 4-29-21 (right).

Sections without Delta-S

Mill and Thinlay on County Road - Low Volume Cell 8024						
Date	**IRI in/mi**	**Locked Wheel Friction FN_{40}**	**Fatigue**	**Raveling**	**# Transverse Cracks**	**Reflected Cracks**
2016, Untreated	88.0	47.8	NA	NA	NA	NA
2016, Treated	33.5	55.5	0	0	0	0%
April-May 2017, Treated	36.2	54.4	0	0	7	100%
September 2017, Treated	37.4	52.0	0	0	8	100%
May 2018, Treated	42.7	54.4	0	0	8	100%
May 2019, Treated	48.6	53.2	0	0	8	100%
June-August 2020, Treated	53.9	57.1	0	0	10	100%
May 2021, Treated	60.2	54.8	0	0	11	100%
Mill and Thinlay on US Highway - High Volume Cell 169026						
Date	**IRI in/mi**	**Locked Wheel Friction FN_{40}**	**Fatigue**	**Raveling**	**# Transverse Cracks**	**Reflected Cracks**
2016, Untreated	81.1	46.7	NA	NA	NA	NA
2016, Treated	44.0	48.5	0	0	0	0%
July 2017, Treated	41.0	51.1	0	0	14	83%
May 2018, Treated	75.2	53.7	0	0	14	90%
May 2019, Treated	74.2	55.3	0	0	26	57%*
June-August 2020, Treated	61.9	58.1	0	0	27	65%
May 2021, Treated	72.9	54.9	0	0	31	70%
(*) 2019 Decrease in Thinlay Reflected Cracks (driving lane) was not due to patching or healing. Reduction resulted after additional working transverse cracks were identified in the Passing Lane (PL micro surfacing placed 2016).						

Cell 8024 Thinlay No Delta-S as constructed in 2016 (left) and inspected 4/28/21 (right).

Cell 169026 Thinlay No Delta-S as constructed in 2016 and inspected 4-29-21 (right).

Control Sections

Control on County Road - Low Volume Cells (Avg) 8019-8022, 8025-8027, 8030, 8031						
Date	**IRI in/mi**	**Locked Wheel Friction FN_{40}**	**Fatigue**	**Raveling**	**# Transverse Cracks**	**Reflected Cracks**
Typical 2016	103.4	49.7	17	21	8	NA
Typical 2017	102.4	51.7	30	24	10	NA
Typical 2018	123.2	52.5	37	29	15	NA
Typical 2019	134.6	51.1	99	76	22	NA
Typical 2020	132.4	52.5	174	111	29	NA
Typical 2021	139.8	52.9	189	113	30	NA
Control on US Highway - High Volume Cells (Avg) 169000, 169014-169016, 169018, 169020, 169021, 169028						
Date	**IRI in/mi**	**Locked Wheel Friction FN_{40}**	**Fatigue**	**Raveling**	**# Transverse Cracks**	**Reflected Cracks**
Typical 2016	78.0	48.5	306	455	24	NA
Typical 2017	81.0	50.8	376	696	30	NA
Typical 2018	87.9	52.0	655	635	31	NA
Typical 2019	91.6	50.7	713	1114	37	NA
Typical 2020	95.4	53.2	854	1334	39	NA
Typical 2021 *	93.9	50.7	585	1110	38	NA
(*) 2021 Decreases in some measures may be affected by micro surfacing placed on 1690015 and 1690016 at the end of the previous year.						

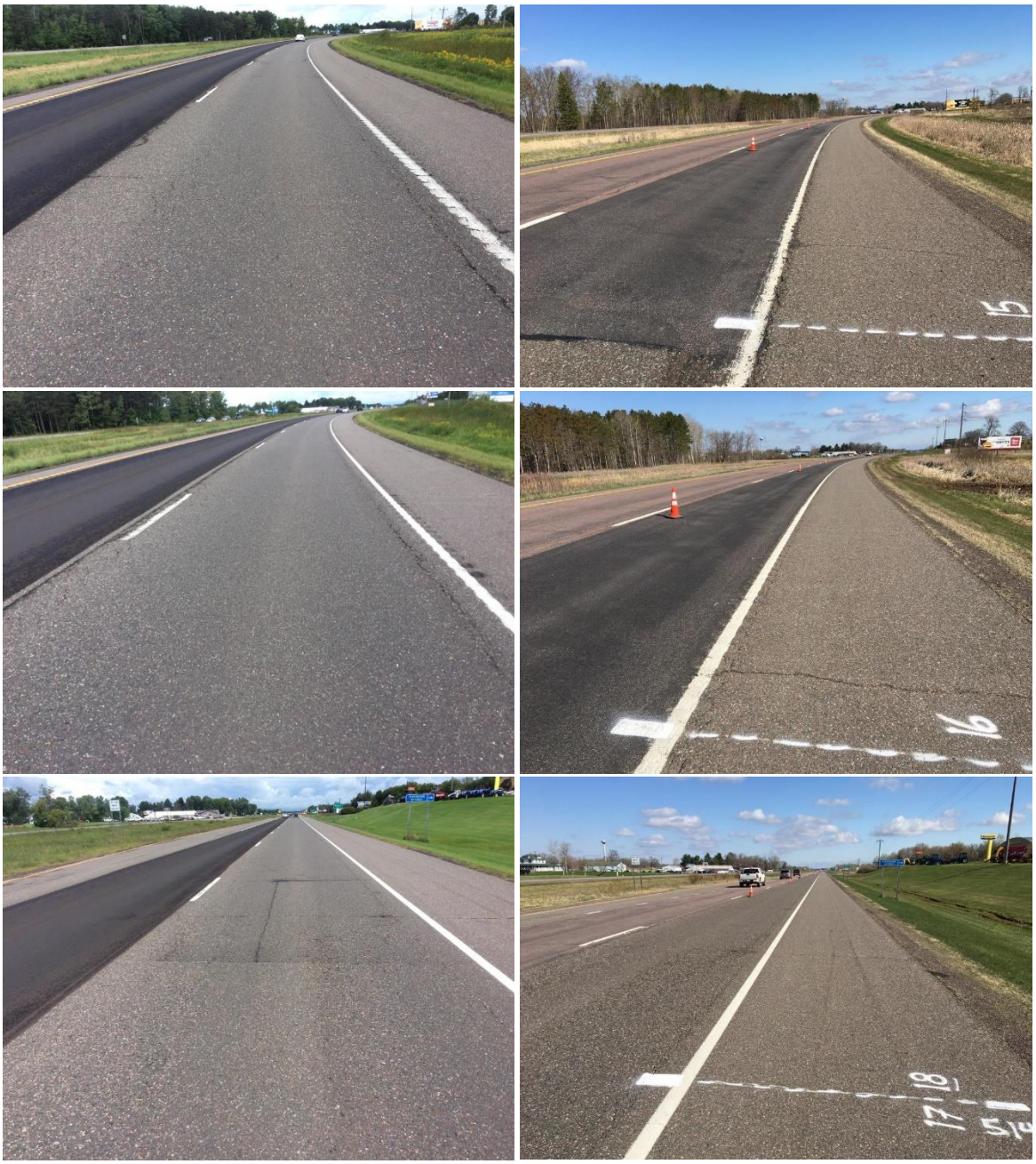
Controls: Cell 8019 (top), 8020 (bottom) inspected in 2016 (left) and 2020-21 (right).

Controls: Cell 8021 (top), 8022 (middle), 8025 (bottom) inspected in 2016 (left) and 2020-21 (right).

Controls: Cell 8026 (top), 8027 (middle), 8030 (bottom) inspected in 2016 (left) and 2020-21 (right).

Controls: Cell 8031 inspected in 2016 (left) and 2020-21 (right).

Controls: Cell 169000 (top), 169014 (bottom) inspected in 2016 (left) and 2020-21 (right).

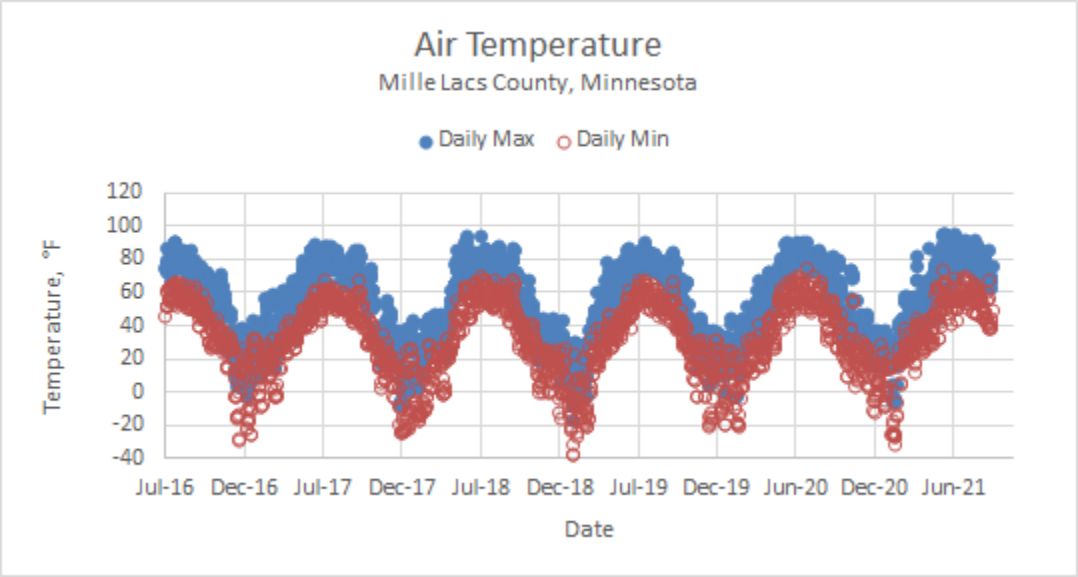


Controls: Cell 169015 (top), 169016 (middle), 169018 (bottom) inspected in 2016 (left) and 2020-21 (right).

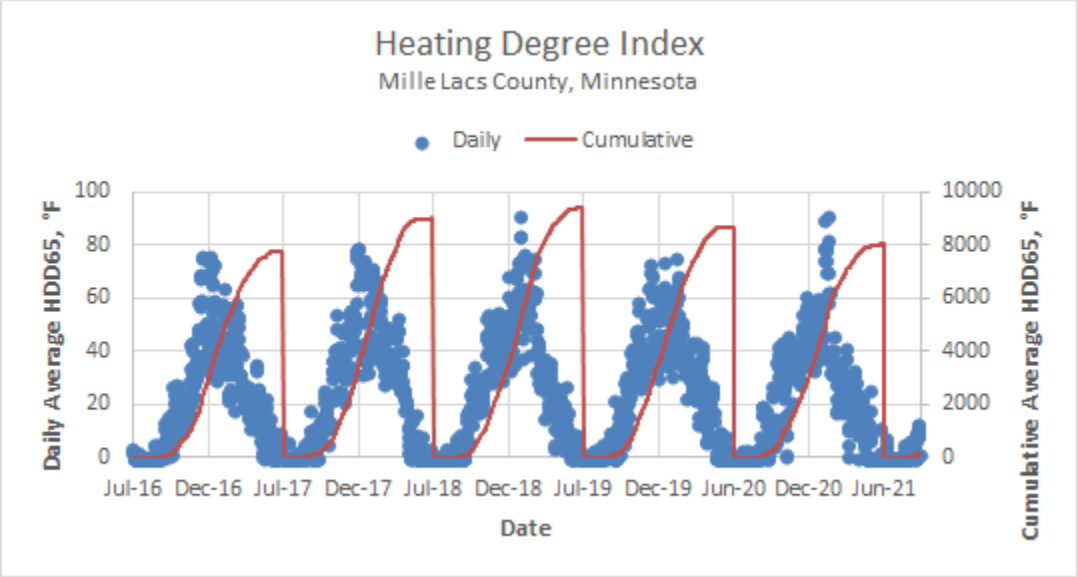
Controls: Cell 169020 (top), 169021 (middle), 169028 (bottom) inspected in 2016 (left) and 2020-21 (right).

Temperature Data

The test sections serve in typical central Minnesota environmental conditions. The climate data available from www.dnr.state.mn.us is summarized below.



Daily High and Low Temperatures during the first five years of the preservation study.



Heating Degree Days during the first five years of the preservation study.