MnDOT's EXPERIENCE

Micro Milling with Surface Treatments

Introduction

The Minnesota Department of Transportation (MnDOT) began investigating the performance of micro milling with surface treatments in 2013. Pavement Interactive defines micro milling as follows:

Figure 1 - Finished micro mill texture of TH 89

The goal of this investigation is to use data gathered by MnDOT personnel to determine the effectiveness of micro milling with surface treatments at improving ride quality. For the purposes of this investigation, the ride quality data is an average of the left and right wheel paths known as the Mean Roughness Index (MRI). This is to keep the data concise due to multiple projects being investigated for each treatment type. The MRIs were collected with an inertial profiler using a line laser setup.

The surface treatments placed in conjunction with micro mills include chip seal, micro surface, and Ultra-Thin Bonded Wear Course (UTBWC). There have been several projects that have incorporated these different surface treatments with a micro mill. This investigation will examine the performance of these different treatments. The project locations can be found at the end of this document in the Appendix.

Treatment #1: Micro Mill with Chip Seal

Ride quality data has been collected on two different micro mill and chip seal projects for this investigation. The data is outlined in the table and chart below. From the data, it appears there is an improvement in MRI over the first two to four years. By the third or fourth year following treatment, the MRI appears to return to approximately the same value as before the treatment. This means that for a relatively small cost, the ride quality of a pavement can be improved for two to four years by micro-milling and chip sealing.

Figure 2 - TH 89 after placement of chip seal

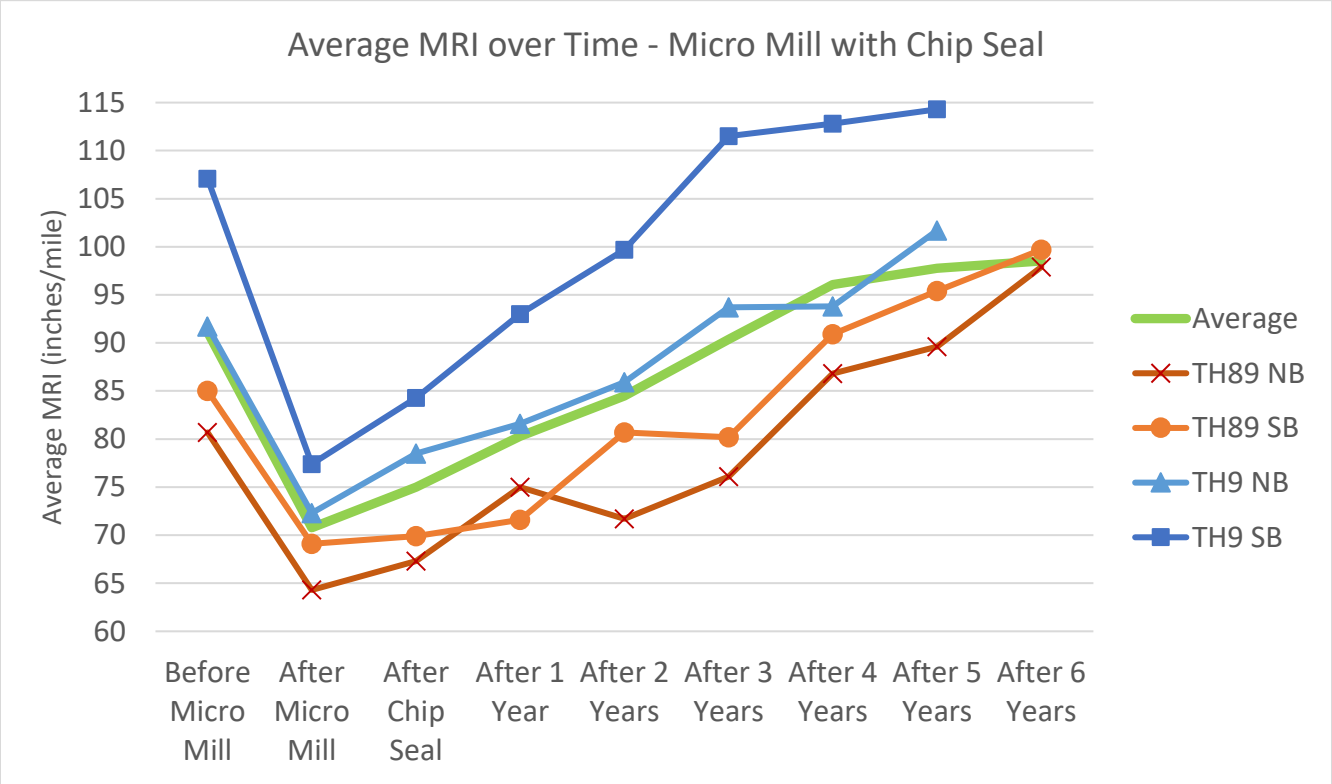

Figure 3 – Micro mill with chip seal performance chart

The data shown in Figure 3 is tabulated below. On all tables in this report, the "% Change" columns refer to the percent difference in MRI for a given year compared to the pre-treatment value. It should be noted that a section of TH 89 was crack sealed in 2018. This section has slightly different performance than the rest of the project, and is shown in the table.

Performance of Micro Milling with Chip Seal																	
Highway (Construction Year)	Before Micro Mill	After Micro Mill		After Chip Seal		After 1 Year		After 2 Years		After 3 Years		After 4 Years		After 5 Years		After 6 Years	
	Avg. MRI (in/mi)	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change
TH 89 NB (2013)	80.7	64.3	20%	67.3	17%	75.0	7%	71.7	11%	76.1	6%	86.8	-8%	89.6	-11%	97.9	-21%
TH 89 SB (2013)	85.0	69.1	19%	69.9	18%	71.6	16%	80.7	5%	80.2	6%	90.9	-7%	95.4	-12%	99.7	-17%
TH 89 NB Crack Seal (2018)	-	-	-	-	-	-	-	-	-	-	-	-	-	85.7	-6%	90.6	-12%
TH 89 SB Crack Seal (2018)	-	-	-	-	-	-	-	-	-	-	-	-	-	99.9	-18%	105.9	-25%
TH 9 NB (2014)	91.7	72.3	21%	78.5	14%	81.6	11%	85.9	6%	93.7	-2%	93.8	-2%	101.7	-11%	-	-
TH 9 SB (2014)	107.1	77.4	28%	84.3	21%	93.0	13%	99.7	7%	111.5	-4%	112.8	-5%	114.3	-7%	-	-
Averages	91.1	70.8	22%	75.0	18%	80.3	12%	84.5	7%	90.4	1%	96.1	-6%	97.8	-11%	98.5	-19%

Table 1: Performance of micro milling with chip seal

It is also worth noting that TH 89 included a control section, which was chip sealed without micro milling. Without the smoothing benefits of micro milling, this section showed a continued degradation in ride quality over time.

Performance of TH89 Chip Seal Without Micro Mill															
Highway (Construction Year)	Before Chip Seal	After Chip Seal		After 1 Year		After 2 Years		After 3 Years		After 4 Years		After 5 Years		After 6 Years	
	Avg. MRI (in/mi)	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change
TH89 NB (2013)	95.7	95.9	0%	110	-15%	101.2	-6%	104.7	-9%	115.3	-20%	118.2	-24%	127.5	-33%
TH89 SB (2013)	80.1	78.3	2%	85.5	-7%	79.7	0%	89.9	-12%	104.2	-30%	103.0	-29%	110.7	-38%
Averages	87.9	87.1	1%	97.8	-11%	90.5	-3%	97.3	-11%	109.8	-25%	110.6	-26%	119.1	-36%

Table 2: Performance of chip seal control section

At approximately $20,000 per lane mile, micro milling with chip sealing can improve the ride quality of a bituminous pavement.

Treatment #2: Micro Milling with Micro Surfacing

Three micro mill with micro surfacing projects and their respective MRI data have been analyzed for this investigation. From this data, there appears to be a significant improvement to ride quality on two of the three projects when compared to the original surface. More data will need to be collected to determine the longevity of the improvements in ride quality. It should be noted that, while the section on US 12 had an initial ride improvement lasting about four years, it then returned to and exceeded its pre-treatment MRI values in the subsequent years. The micro mill and micro surfacing on US 12 was placed on a bituminous overlay over concrete pavement.

Figure 4 - TH 64 after 1 year

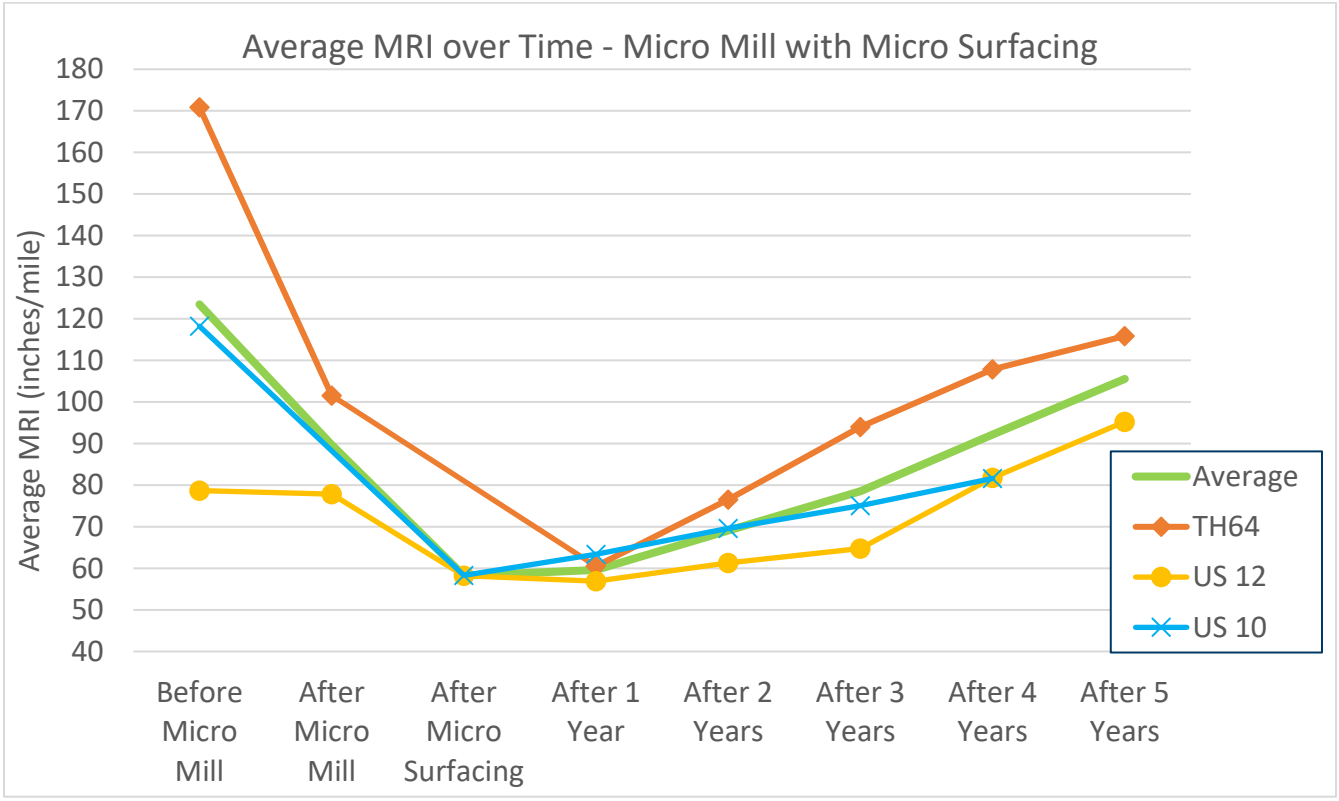

Figure 5 – Micro mill with micro surfacing chart

The data shown in Figure 5 is tabulated below.

Performance of Micro Milling with Micro Surfacing															
Highway (Construction Year)	Before Micro Mill	After Micro Mill		After Micro Surfacing		After 1 Year		After 2 Years		After 3 Years		After 4 Years		After 5 Years	
	Avg. MRI (in/mi)	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change
TH 64 NB (2014)	166.3	99.6	40%	-	-	61.4	63%	77.3	54%	92.5	44%	104.5	37%	114.8	31%
TH 64 SB (2014)	175.4	103.5	41%	-	-	59.6	66%	75.8	57%	95.5	46%	111.1	37%	116.9	33%
US 12 EB (2014)	77.7	76.2	2%	58.2	25%	57.2	26%	62.9	19%	65.6	16%	85.3	-10%	101.9	-31%
US 12 WB (2014)	79.7	79.5	0%	58.2	27%	56.6	29%	59.7	25%	63.9	20%	78.3	2%	88.6	-11%
US 10 EB Driving Lane (2015)	118.2	-	-	58.3	51%	63.4	46%	69.6	41%	75.1	36%	81.6	31%	-	-
Averages	123.5	89.7	21%	58.2	34%	59.6	46%	69.1	39%	78.5	32%	92.2	19%	105.6	6%

Table 3: Performance of micro milling with micro surfacing

At approximately $30,000 per lane mile, micro milling with micro surfacing can greatly improve the ride quality of a bituminous pavement.

Treatment #3: Micro Mill with UTBWC

This investigation analyzed the ride data on two different micro mill with UTBWC projects. The data shows that ride quality can be significantly improved compared to the original surface. After 5 years, there is an average improvement of 34% on US 10 compared to the pre-treatment MRI. It is also worth mentioning that the micro mill and UTBWC placed on I-394 gave it the best ride quality it has ever had - even better than after it was newly constructed. As an interesting hypothetical exercise, if one were to apply MnDOT smoothness equation HMA-C to any of the average MRIs on I-394 today, they would still be in the incentive range (and this is 3 years after construction).

As with micro surfacing, more ride data will need to be collected in subsequent years since the sections in this report have not yet returned to their pre-treatment MRI values. Additional ride quality data will provide further insight into the effectiveness of micro milling with UTBWC at improving ride and preserving pavement condition, but current results are very promising.

Figure 6 – US 10 After 1 Year

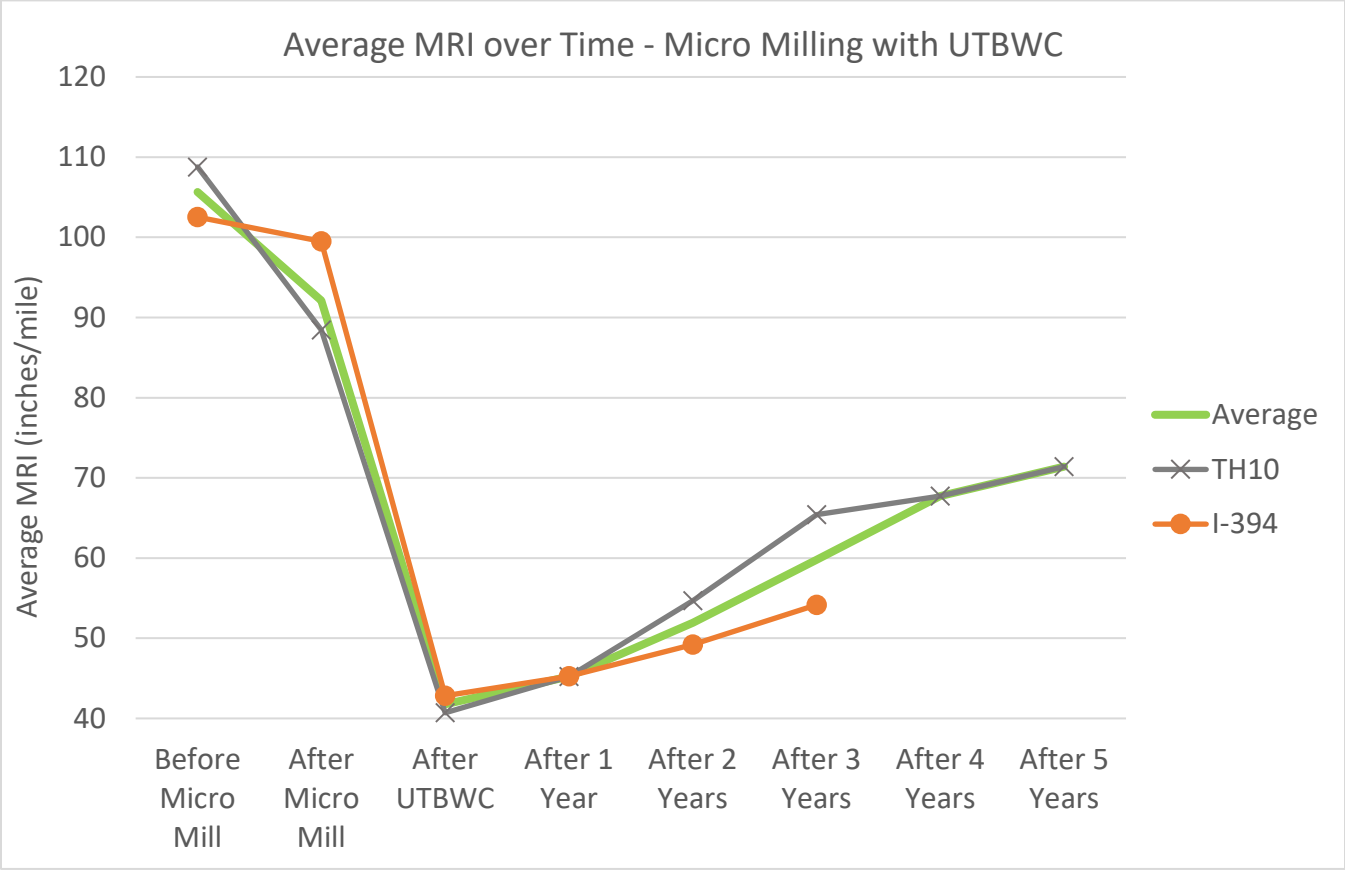

Figure 7 – Micro Mill with UTBWC Chart

The data shown in Figure 7 is tabulated below.

Performance of Micro Milling with UTBWC															
Highway (Construction Year)	Before Micro Mill	After Micro Mill		After UTBWC		After 1 Year		After 2 Years		After 3 Years		After 4 Years		After 5 Years	
	Avg. MRI (in/mi)	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change	Avg. MRI (in/mi)	% Change
TH10 EB Driving Lane (2014)	105.9	-	-	42.0	60%	46.2	56%	57.6	46%	67.1	37%	70.0	34%	71.3	33%
TH10 EB Passing Lane (2014)	109.0	90.4	17%	41.2	62%	45.1	59%	54.1	50%	64.0	41%	64.4	41%	69.7	36%
TH10 WB Driving Lane (2014)	109.4	-	-	39.4	64%	44.0	60%	54.8	50%	64.9	41%	67.6	38%	70.3	36%
TH10 WB Passing Lane (2014)	110.8	86.5	22%	40.2	64%	45.6	59%	52.2	53%	65.6	41%	68.9	38%	74.3	33%
I-394 EB Driving Lane (2016)	93.1	-	-	43.9	53%	46.2	50%	48.2	48%	54.0	42%	-	-	-	-
I-394 EB Passing Lane (2016)	105.8	-	-	41.5	61%	44.6	58%	48.7	54%	52.9	50%	-	-	-	-
I-394 WB Driving Lane (2016)	97.9	99.5	-2%	42.8	56%	45.3	54%	49.0	50%	55.4	43%	-	-	-	-
I-394 WB Passing Lane (2016)	113.3	-	-	43.1	62%	44.9	60%	50.9	55%	54.5	52%	-	-	-	-
Averages	105.7	92.1	12%	41.8	60%	45.2	57%	51.9	51%	59.8	43%	67.7	38%	71.4	34%

Table 4: Performance of micro milling with UTBWC

At approximately $43,000 per lane mile, micro milling with UTBWC has shown the best results at improving ride quality within the scope of this investigation. While it has the highest initial cost of the three treatments detailed herein, it may be the most effective at improving ride quality long-term.

Conclusions

As discussed above, since the MRI of most of the micro surfacing and UTBWC sections have not yet returned to the original values, additional ride data will need to be collected in subsequent years to provide a true comparison of cost/benefit ratio and longevity of the different treatments. Based on the available data, it is clear that micro milling in combination with surface treatments has the potential to greatly improve ride quality of a bituminous pavement.

Please see the MnDOT Pavement Preservation Manual for more information on preventive maintenance surface treatments.

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Reference

"Micro-Milling - The Finer Side of Milling." Pavement Interactive, 14 Sept. 2018, www.pavementinteractive.org/micro-milling-the-finer-side-of-milling/

DEPARTMENT OF TRANSPORTATION

Appendix

The following table lists the approximate reference post numbers corresponding to each project location:

Micro Mill Project Limits		
Chip Seal Projects	**Reference Post Limits**	**Length (mi)**
TH 89 Control Section	59.0 - 60.0	1.0
TH 89 Micro Mill Section	60.0 - 71.3	11.3
TH 89 Micro Mill with Crack Seal Section	71.3 - 74.0	2.7
TH 9	119.8 - 132.8	13.0
Micro Surfacing Projects	**Reference Post Limits**	**Length (mi)**
US 10 (eastbound only)	78.6 - 86.8	8.2
US 12	67.4 - 72.9	5.5
TH 64	0 - 18.7	18.7
UTBWC Projects	**Reference Post Limits**	**Length (mi)**
I-394	0 - 6.3	6.3
US 10	116.2 - 131.6	15.4

Table 5: Micro Mill Project Reference Post Limits