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14. Supplementary Notes			
15. Abstract Objective Past literature has indicated that pavements that are initially built smoother, stay smoother longer, thus improving overall ride quality for a longer period of time. Past research has also shown that smoother pavements reduce maintenance costs over the life of the pavement. The North Dakota Department of Transportation (NDDOT) has developed a Strategic Business Plan (SBP) to help improve customer satisfaction within the state of North Dakota. The plan outlines a number of objectives in order to accomplish this plan. The desired outcome of SBP Objective 1.3 is to improve overall ride quality of North Dakota's roads by 10%. There is a need to replace the profilograph with a device that measures ride quality that simulates what the user feels in the car. Scope Data will be collected with both the LWP and HSP to be used to determine the resources required for implementation of a ride quality specification. Summary It is recommended not to use the shadow vehicle when profiling a project with the LWP. The shadow vehicle made passing the paving train more difficult. Removing the shadow vehicle will allow passing traffic to pass without being in the other lane as long. The HSP will profile projects much faster than the LWP. The HSP is recommended to be used when the traffic speeds allow. For areas where the speed limit and geometrics prevent the HSP from being used the LWP will be used. It is also recommended to use the RoLine lasers for a surface that has longitudinal tining or has been ground. A roadway with the entire surface having a longitudinal tined or ground surface should be profiled with the RoLines lasers. These lasers will provide a more accurate measurement of the IRI.			
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NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION
MATERIALS AND RESEARCH
DIVISION

Experimental Study ND 2005-01

**Evaluation of a Light Weight Profiler
(LWP) for Collection of Ride Quality Data
on Asphalt and Concrete Pavements**

Final Report

March 2009

Prepared by

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EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT	EXPERIMENTAL PROJECT NO.				CONSTRUCTION PROJ NO	LOCATION
	STATE	Y EAR	NUMBER	SURF		
	1 ND	2005	01		8	28
EVALUATION FUNDING	NEEP NO.				PROPRIETARY FEATURE?	
	1 X	HP&R	3	DEMONSTRATION		Yes
48	2	CONSTRUCTION	4	IMPLEMENTATION	49	51 X No
SHORT TITLE	TITLE Evaluation of a Light Weight Profiler (LWP) for Collection of Ride Quality Data on Asphalt and Concrete Pavements					
THIS FORM	DATE	MO.	YR.	REPORTING		
	140	09	--	2007	1 INITIAL	2 ANNUAL 3 X FINAL
KEY WORDS	KEY WORD 1			KEY WORD 2		
	145 International Roughness Index			167 IRI		
	KEY WORD 3			KEY WORD 4		
	189 Lightweight Profiler			211 LWP		
UNIQUE WORD			PROPRIETARY FEATURE NAME			
233			255			
CHRONOLOGY	Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:	
	277 04-2005	281	285 12-2007	289	293	
QUANTITY AND COST	QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS)		UNITS		UNIT COST (Dollars, Cents)	
	1		1 LIN. FT	5 TON	\$49,425.00	
			2 SY	6 LBS		
		3 SY-IN	7 EACH			
		4 CY	8 X LUMP SUM			
297		305		306		
AVAILABLE EVALUATION REPORTS	CONSTRUCTION		PERFORMANCE		FINAL	
	315					
EVALUATION	CONSTRUCTION PROBLEMS			PERFORMANCE		
	1 X	NONE		1	EXCELLENT	
2	SLIGHT		2	GOOD		
3	MODERATE		3	SATISFACTORY		
4	SIGNIFICANT		4	MARGINAL		
318	5	SEVERE	319	5	UNSATISFACTORY	
APPLICATION	1	ADOPTED AS PRIMARY STD.	4 X	PENDING	(Explain in remarks if 3, 4, 5, or 6 is checked)	
	2	PERMITTED ALTERNATIVE	5	REJECTED		
	320	3	ADOPTED CONDITIONALLY	6		
REMARKS	321 The NDDOT purchased a high speed profiler since this project has begun. This profiler will be incorporated into this research project.					

Experimental Study ND 2005-01

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FINAL REPORT

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Written by

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Kyle Evert

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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Evaluation of a Light Weight Profiler (LWP) for Collection of Ride Quality Data on Asphalt and Concrete Pavements

ND 2005-01

Purpose and Need

Past literature has indicated that pavements that are initially built smoother, stay smoother longer, thus improving overall ride quality for a longer period of time. Past research has also shown that smoother pavements reduce maintenance costs over the life of the pavement.

The North Dakota Department of Transportation (NDDOT) has developed a Strategic Business Plan (SBP) to help improve customer satisfaction within the state of North Dakota. The plan outlines a number of objectives in order to accomplish this plan. The desired outcome of SBP Objective 1.3 is to improve overall ride quality of North Dakota's roads by 10%.

The NDDOT developed a Flexible Pavement Surface Tolerance Special Provision (SP) in 2005 for a ride specification on asphalt pavements constructed or rehabilitated within the state to support SBP Objective 1.3. The ride quality index used is the International Roughness Index (IRI) which is measured in inches per mile (in/mile). Prior to the SP, North Dakota did not have a ride specification for asphalt pavements.

The NDDOT has had a ride specification on concrete pavements for many years that uses a California-style profilograph to evaluate new or rehabilitated concrete pavements. The California-style profilograph uses the Profile Index (PI) which is measured in inches per mile (in/mile) to measure ride quality. The profilograph is capable of adequately finding bumps; however, it does not accurately reflect the quality of the ride as experienced by the user. The IRI is a more accurate measurement of ride quality as it simulates what the user feels driving down the road.

While the IRI and PI have the same units, the values are not interchangeable as the measurement and calculations are different.

There is a need to replace the profilograph with a device that measures ride quality that simulates what the user feels in the car.

Objective

The Planning and Programming Division uses a Pathrunner XP Model PSI3 LG high speed inertial profiler to collect data on a state basis which is used for pavement management. While the Pathrunner XP Model PSI3 LG profiler can collect the data we are interested in, this equipment is expensive and does not have the time availability to collect project specific data during construction. Other disadvantages with using the Pathrunner XP Model PSI3 LG are the turnaround times needed to analyze the data. The equipment is not light enough to be used on new concrete pavements within the first few days.

The original objective of this research was to evaluate the use of a Light Weight Inertial Profiler (LWP) in collecting ride quality data. The data collected then would be used to determine the resources required for implementation of a ride quality specification. During the course of this research project Materials and Research purchased a bumper mounted High Speed Inertial Profiler (HSP). The collection of data with the HSP will be combined with the intent of the original objective. Data will be collected with both the LWP and HSP to be used to determine the resources required for implementation of a ride quality specification.

Location

The NDDOT collected ride quality data on 11 projects in 2006. Refer to Figure 1 on the next page for project locations.

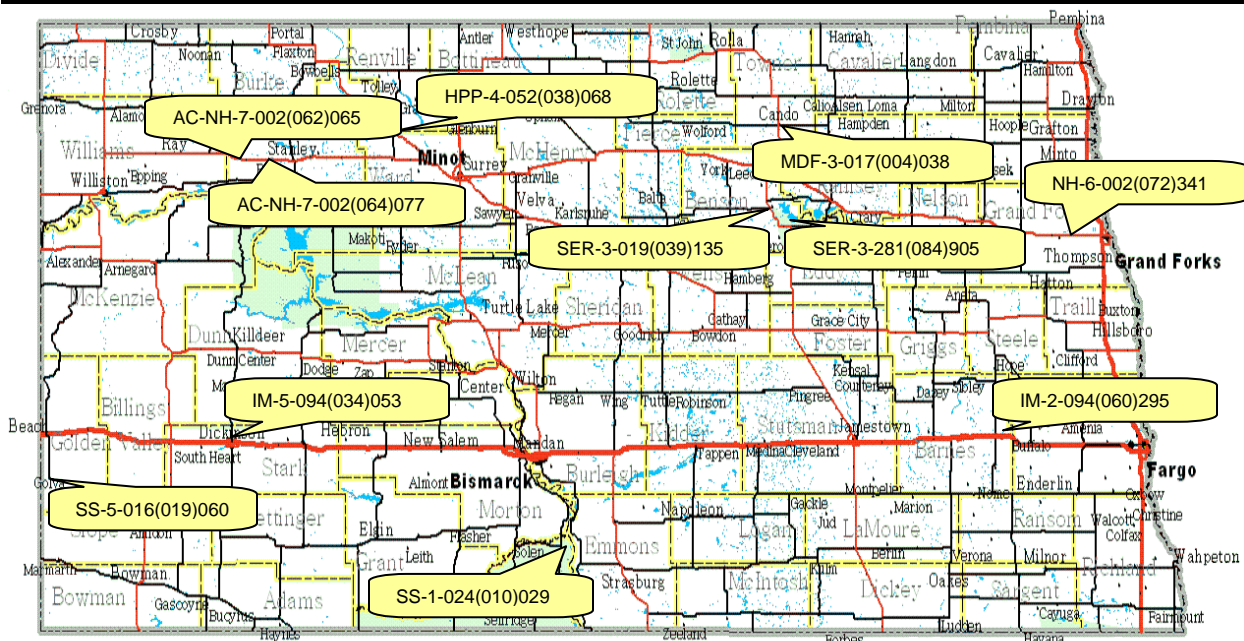


Figure 1 – Map of project locations.

Equipment

Ames Engineering is the manufacturer that won the bid for the LWP as stated in the year one research report. The Final Report will use the original single point laser and Ames RoLine lasers. New Roline lasers were purchased in August of 2006. These lasers use a line laser that runs perpendicular to the roadway. They use different points along the laser line to develop an algorithmic average for the profile heights of the peaks and valleys of a pavement texture. This works well with concrete that has grinding or longitudinal tining. A regular single point laser will fall in between peaks and valleys of the grooves of textured pavement giving a false profile elevation. Photo 1 displays the laser line of the Roline laser.

Both the RoLine lasers and the single point lasers are certified annually at the MNROAD's facility. The lasers must meet Minnesota Department of Transportation's specifications to become certified by MnDOT.



Photo 1 – View of line laser on base plate.

Data Collection Resources

Lightweight Profiler (LWP)

The LWP resources required to profile a roadway for a project are the LWP, attenuator, tow vehicle, and 1 operator for each vehicle. The LWP can collect data from speeds of 10 mph to 16 mph. Projects are profiled at 15 mph so the average time to profile on a project was 4 minutes per lane mile. It takes approximately 30 minutes apiece to setup and takedown the LWP. With 3 operators needed to profile a project 3 man hours are required to setup and breakdown the LWP. The length of the project will dictate the time required to profile a project.

The maintenance requirements completed for the LWP can be seen in the table below.

Maintenance Requirements
Oil and filter change at 44.4 hours
Oil and filter change, lube, checked drive belt tension, and rotated front tires at 97.0 hours
Oil and filter change, lube, checked drive belt tension, and rotated front tires at 150.0 hours
Oil and filter change, lube, checked drive belt tension, and replaced front tires at 200.0 hours

Using a pilot vehicle in front of the LWP does cause some problems. It increases the length required for the vehicles to pass the profiling train (pilot vehicle, LWP and attenuator truck as a shadow vehicle). Occasionally, vehicles that attempted to pass the profiling train would maneuver in between the pilot vehicle and LWP. The passing vehicles would pull in between the LWP and pilot vehicle because there would be a vehicle approaching in the other lane. Removing the pilot vehicle from the profiling train would alleviate this problem. Profiling without the pilot vehicle appeared to perform better than profiling with the pilot vehicle. It appears to be no safety hazard to profile with the LWP followed approximately 50' by the attenuator truck. This will reduce the man hours required to profile a project.

High Speed Profiler (HSP)

The HSP resources required to profile a roadway for a project are the HSP, vehicle, and 1 operator for the vehicle. The HSP can collect data from speeds of 35 mph to 60 mph. Projects are profiled at 55 mph unless the speed limit prohibits this speed, to which the project will be profiled at or below the posted speed limit. The average time to profile on a project is approximately one minute per mile. It takes approximately 30 minutes apiece to setup and takedown the HSP. With one operator needed to profile a project one man hour is required to setup and breakdown the LWP. The length of the project will dictate the time required to profile a project.

The maintenance requirements for the HSP are the standard NDDOT

maintenance requirements for a state owned vehicle.

HBP Pavement Data Analysis

ProVAL will be the software used to analyze the profiling data. ProVAL is a free software provided by Federal Highway Administration. The software can analyze data from different profilers to provide a IRI value. The data will be analyzed using 0.1 mile lots, 0.05 mile lots and 264' long "sliding lots". The sliding lots are a moving average IRI at each point down the roadway. The benefit of using a sliding average is to eliminate the chance of a bump beginning or ending a lot. The analyzed data will then be compared using the ride quality incentives/disincentives, from the Flexible Pavement Surface Tolerance Special Provision, for the type of project constructed.

The Flexible Pavement Surface Tolerance Special Provision was applied to three types of projects; mine and blend or new construction, structural overlay (2 or more lifts), and thin lift overlays. Each type of project had different ride quality requirements (IRI limits) and the thin lift overlay project requirements were based on the existing ride quality of the road. Eleven projects with the Flexible Pavement Surface Tolerance Special Provision had ride quality data collected and analyzed for HBP highways.

Mine and Blend or New Construction Projects

There was one mine and blend project and four new grading projects where ride quality data was collected for 2006. These projects applied a Flexible Pavement Surface Tolerance Provision to the ride statistics. The pay bands for the SP can be found in Appendix A.

AC-NH-7-002(062)065

This project was new construction and was part of constructing US 2 into a four lane roadway. The total pavement section consisted of 15.0" of dense graded aggregate and 5.5" of HBP. The bottom 3.5" of HBP had PG 58-28 asphalt cement and the top 2.0" had PG 58-34 asphalt cement. Ride quality data was collected on 10-16-2006. Tables 1 and 2 are a summary of the ride quality data and incentives / disincentives according to the 2006 Flexible Pavement Surface Tolerance SP.

Number of lots within the range					
2006 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=32.0	68	27.42%	174	35.1%	34.9%
32.1 to 36.0	64	25.81%	91	18.4%	19.0%
36.1 to 39.0	26	10.48%	60	12.1%	10.5%
39.1 to 42.0	19	7.66%	34	6.9%	8.8%
42.1 to 50.0	50	20.16%	79	15.9%	16.5%
50.1 to 57.0	13	5.24%	40	8.1%	6.5%
57.1 to 64.0	6	2.42%	10	2.0%	2.4%
64.1 to 70.0	2	0.81%	4	0.8%	1.0%
>=70.1	0	0.00%	4	0.8%	0.6%
Total	248	100.0%	496	100.0%	100.0%

Table 1 – Percentage of lots within a lot size range. - AC-NH-7-002(062)065

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
Drive	\$36,700	\$36,950	\$37,237
Pass	\$13,500	\$15,400	\$15,065
Total	\$50,200	\$52,350	\$52,302

Table 2 – Incentive / disincentive project totals. - AC-NH-7-002(062)065

AC-NH-7-002(064)077

This project was new construction. It was part of making US 2 a four lane roadway. The total pavement section consisted of 15.0" of dense graded aggregate and 5.5" of HBP. The bottom 3.5" of HBP had PG 58-28 asphalt cement and the top 2.0" had PG 58-34 asphalt cement. Ride quality data was collected on 10-9-2006. Tables 3 and 4 are a summary of the ride quality data and incentives / disincentives according the 2006 Flexible Pavement Surface Tolerance SP.

Number of lots within the range					
2006 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=32.0	64	26.2%	138	28.3%	27.6%
32.1 to 36.0	35	14.3%	63	12.9%	13.0%
36.1 to 39.0	17	7.0%	48	9.8%	10.5%
39.1 to 42.0	32	13.1%	51	10.5%	11.4%
42.1 to 50.0	62	25.4%	113	23.1%	22.6%
50.1 to 57.0	21	8.6%	44	9.0%	8.6%
57.1 to 64.0	8	3.3%	18	3.7%	3.8%
64.1 to 70.0	5	2.1%	9	1.8%	1.7%
>=70.1	0	0.00%	4	0.8%	0.9%
Total	244	100.0%	488	100.0%	100.0%

Table 3 – Percentage of lots within a lot size range. - AC-NH-7-002(064)077

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
Drive	\$34,700	\$34,400	\$34,120
Pass	\$2,300	\$4,200	\$4,595
Total	\$37,000	\$38,600	\$38,714

Table 4 – Incentive / disincentive project totals. - AC-NH-7-002(064)077

SER-3-019(039)135

This project was new construction. The total pavement section consisted of 18.0" of dense graded aggregate and 5.5" of HBP. The bottom 3.5" of HBP had PG 58-28 asphalt cement and the top 2.0" had PG 58-34 asphalt cement. Ride quality data was collected on 8-21-2006. Tables 5 and 6 are a summary of the ride quality data and incentives / disincentives according the 2006 Flexible Pavement Surface Tolerance SP.

Number of lots within the range					
2006 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=32.0	3	4.6%	8	6.0%	7.7%
32.1 to 36.0	7	10.6%	25	18.7%	17.0%
36.1 to 39.0	15	22.7%	26	19.4%	18.6%
39.1 to 42.0	10	15.2%	20	14.9%	17.2%
42.1 to 50.0	23	34.9%	33	24.6%	24.1%
50.1 to 57.0	5	7.6%	12	9.0%	7.9%
57.1 to 64.0	1	1.5%	6	4.5%	3.3%
64.1 to 70.0	2	3.0%	2	1.5%	2.0%
>=70.1	0	0.00%	2	1.5%	2.1%
Total	66	100.0%	134	100.0%	100.0%

Table 5 – Percentage of lots within a lot size range. - SER-3-019(039)135

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
WB	\$4,100	\$4,800	\$4,819
EB	\$1,700	\$2,550	\$2,680
Total	\$5,800	\$7,350	\$7,499

Table 6 – Incentive / disincentive project totals. - SER-3-019(039)135

HPP-4-052(038)068

This project was a mine and blend construction project. The base section consisted of 11" of existing HBP and aggregate base blended with 7" virgin aggregate. The pavement section consists of 5.5" of Superpave HBP. The bottom 3.5" of HBP had PG 58-28 asphalt cement and the top 2.0" had PG 58-34 asphalt cement. Ride quality data was collected on 8-2-2006. Tables 7 and 8 are a summary of the ride quality data and incentives / disincentives according to the 2006 Flexible Pavement Surface Tolerance SP.

Number of lots within the range					
2006 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=34.0	62	24.6%	146	28.9%	28.4%
34.1 to 39.0	94	37.3%	172	34.0%	33.9%
39.1 to 44.0	58	23.0%	96	19.0%	20.3%
44.1 to 48.0	18	7.1%	45	8.9%	8.0%
48.1 to 56.0	16	6.3%	29	5.7%	6.4%
56.1 to 62.0	1	0.4%	11	2.2%	2.2%
62.1 to 69.0	2	0.8%	4	0.8%	0.5%
69.1 to 75.0	0	0.0%	1	0.2%	0.1%
>=75.1	1	0.4%	2	0.4%	0.3%
Total	252	100.0%	506	100.0%	100.0%

Table 7 – Percentage of lots within a lot size range. - HPP-4-052(038)068

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
WB	\$24,150	\$24,488	\$24,394
EB	\$25,275	\$24,788	\$24,743
Total	\$49,425	\$49,275	\$49,137

Table 8 – Incentive / disincentive project totals. - HPP-4-052(038)068

SER-3-281(084)905

This project was new construction. The total pavement section consisted of 18.0" of dense graded aggregate and 5.5" of HBP. The bottom 3.5" of HBP had PG 58-28 asphalt cement and the top 2.0" had PG 58-34 asphalt cement. Ride quality data was collected on 8-22-2006. Tables 9 and 10 are a summary of the ride quality data and incentives / disincentives according the 2006 Flexible Pavement Surface Tolerance SP.

Number of lots within the range					
2006 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=32.0	4	5.4%	19	12.7%	14.0%
32.1 to 36.0	24	32.4%	36	24.0%	25.0%
36.1 to 39.0	16	21.6%	33	22.0%	17.6%
39.1 to 42.0	10	13.5%	19	12.7%	15.7%
42.1 to 50.0	14	18.9%	28	18.7%	18.7%
50.1 to 57.0	3	4.1%	9	6.0%	5.1%
57.1 to 64.0	2	2.7%	1	0.7%	1.3%
64.1 to 70.0	0	0.0%	2	1.3%	1.3%
>=70.1	1	1.4%	3	2.0%	1.2%
Total	74	100.0%	150	100.0%	100.0%

Table 9 – Percentage of lots within a lot size range. - SER-3-281(084)905

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
NB	\$5,600	\$5,600	\$5,666
SB	\$6,700	\$6,900	\$6,859
Total	\$12,300	\$12,500	\$12,526

Table 10 – Incentive / disincentive project totals. - SER-3-281(084)905

Structural Overlay Projects

There were two structural overlay projects where ride quality data was collected. One project had a Flexible Pavement Surface Tolerance Special Provision applied to the project. Refer to Appendix A for the SP pay bands regarding Structural Overlays.

NH-6-002(072)341

The structural overlay on this project consisted of 2.5" of HBP with PG 58-28 asphalt cement. The initial average IRI value on this project was 95 in/mile. Ride quality data was collected on 10-9-2006. Tables 11 and 12 are a summary of the ride quality data and incentives / disincentives according to the 2006 Flexible Pavement Surface Tolerance SP for a Structural Overlay. This project was constructed under the ride quality specification.

Number of lots within the range

2006 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=34.0	11	4.4%	43	8.6%	9.9%
34.1 to 39.0	46	18.3%	106	21.2%	21.8%
39.1 to 44.0	67	26.6%	113	22.6%	24.3%
44.1 to 48.0	47	18.7%	71	14.2%	14.4%
48.1 to 56.0	49	19.4%	96	19.2%	16.8%
56.1 to 62.0	22	8.7%	41	8.2%	6.6%
62.1 to 69.0	8	3.2%	20	4.0%	3.5%
69.1 to 75.0	2	0.8%	6	1.2%	1.5%
>=75.1	0	0.0%	4	0.8%	1.2%
Total	252	100.0%	500	100.0%	100.0%

Table 11 – Percentage of lots within a lot size range. - NH-6-002(072)341

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
Driving	\$15,225	\$15,450	\$15,687
Passing	\$10,425	\$11,888	\$12,356
Total	\$25,650	\$27,338	\$28,043

Table 12 – Incentive / disincentive project totals. - NH-6-002(072)341

IM-2-094(060)295

This project was a mill and overlay for most of the project. Areas under a bridge required grade lowering and a new section was constructed in these locations. The mill and overlay section milled 4" of existing HBP and then overlaid with two lifts. The first lift was 3.5" of HBP with PG 58-28 asphalt cement. The second lift was 2" of HBP with PG 64-28 asphalt cement. The new sections under the bridge were 21" of blended base with 5.5" of HBP. The HBP for this section was also paved with two lifts. The first lift was 3.5" of HBP with PG 58-28 asphalt cement. The second lift was 2" of HBP with PG 64-28. The initial average IRI value on this project was 137 in/mile. Ride quality data was collected on 8-16-2006. Tables 13 and 14 are a summary of the ride quality data and incentives / disincentives according to the 2006 Flexible Pavement Surface Tolerance SP for a Structural Overlay. This project was constructed under the ride quality specification.

Number of lots within the range					
2006 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=34.0	41	20.3%	82	20.2%	20.4%
34.1 to 39.0	24	11.9%	57	14.0%	14.1%
39.1 to 44.0	27	13.4%	63	15.5%	14.4%
44.1 to 48.0	32	15.8%	49	12.1%	14.0%
48.1 to 56.0	54	26.7%	100	24.6%	23.0%
56.1 to 62.0	12	5.9%	35	8.6%	8.2%
62.1 to 69.0	8	4.0%	7	1.7%	2.7%
69.1 to 75.0	3	1.5%	6	1.5%	1.6%
>=75.1	1	0.5%	7	1.7%	1.4%
Total	202	100.0%	406	100.0%	100.0%

Table 13 – Percentage of lots within a lot size range. - IM-2-094(060)295

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
Driving	\$19,650	\$19,350	\$19,231
Passing	\$1,500	\$3,188	\$3,036
Total	\$21,150	\$22,538	\$22,268

Table 14 – Incentive / disincentive project totals. - IM-2-094(060)295

Thin Lift Overlay Projects – Initial IRI Values Less Than 133.0 in/mile

There was one thin lift overlay project with an initial IRI value of less than 133.0 in/mile where ride quality data was collected. This project had a Flexible Pavement Surface Tolerance Special Provision applied to the project. Refer to Appendix A for the SP pay bands regarding Thin Lift Overlays with an initial IRI value of less than 133.0 in/mile.

SS-5-016(019)060

The thin lift overlay on this project consisted of 1.5" of HBP with PG 58-28 asphalt cement. The initial average IRI value on this project was 60.1 in/mile. Ride quality data was collected on 8-9-2006. Tables 15 and 16 are a summary of the ride quality data and incentives / disincentives according the 2006 Flexible Pavement Surface Tolerance SP for a thin lift overlay with an initial IRI value of less than 133.0 in/mile.

Number of lots within the range

2005 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=47.0	228	72.2%	447	70.7%	71.5%
47.1 to 57.0	50	15.8%	103	16.3%	15.1%
57.1 to 67.0	21	6.6%	43	6.8%	6.8%
67.1 to 72.0	5	1.6%	15	2.4%	2.0%
72.1 to 82.0	8	2.5%	14	2.2%	2.6%
>=82.1	4	1.3%	10	1.6%	2.1%
Total	316	100.0%	632	100.0%	100.0%

Table 15 – Percentage of lots within a lot size range. - SS-5-016(019)060

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
Driving	\$19,550	\$19,050	\$19,027
Passing	\$15,700	\$15,700	\$11,178
Total	\$35,250	\$34,750	\$30,205

Table 16 – Incentive / disincentive project totals. - SS-5-016(019)060

Thin Lift Overlay Projects – Initial IRI Values Greater Than 133.0 in/mile and less than 177.0 in/mile

There were two thin lift overlay projects with an initial IRI value of greater than 133.0 in/mile and less than 177 in/mile where ride quality data was collected. These projects did not have a Flexible Pavement Surface Tolerance Special Provision applied to the project. Refer to Appendix A regarding the SP pay bands thin lift overlays with an initial IRI value of greater than 133.0 in/mile and less than 177.0 in/mile.

MDF-3-017(004)038

The thin lift overlay on this project consisted of 1.5” of HBP with PG 58-28 asphalt cement. The initial average IRI value on this project was 155.5 in/mile. Ride quality data was collected on 7-11-2006. Tables 17 and 18 are a summary of the ride quality data and incentives / disincentives according the 2006 Flexible Pavement Surface Tolerance SP for a Thin Lift Overlay with an initial IRI value greater than 133.0 in/mile and less than 177.0 in/mile.

Number of lots within the range					
2005 Range	0.1 mile	%	0.05 mile	%	264 ft sliding base length
<=51.0	96	33.3%	224	38.9%	38.0%
51.1 to 61.0	135	46.9%	229	39.8%	40.0%
61.1 to 76.0	53	18.4%	103	17.9%	19.0%
76.1 to 81.0	2	0.7%	8	1.4%	1.4%
81.1 to 91.0	2	0.7%	11	1.9%	1.4%
>=91.1	0	0.0%	1	0.2%	0.2%
Total	288	100.0%	576	100.0%	100.0%

Table 17 – Percentage of lots within a lot size range. - MDF-3-017(004)038

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
WB	\$9,150	\$10,100	\$9,684
EB	\$11,600	\$11,400	\$11,486
Total	\$20,750	\$21,500	\$21,169

Table 18 – Incentive / disincentive project totals. - MDF-3-017(004)038

SS-1-024(010)029

The thin lift overlay on this project consisted of 1.5" of HBP with PG 58-28 asphalt cement. The initial average IRI value on this project was 167.8 in/mile. Ride quality data was collected on 6-22-2006. Tables 19 and 20 are a summary of the ride quality data and incentives / disincentives according the 2006 Flexible Pavement Surface Tolerance SP for a Thin Lift Overlay with an initial IRI value greater than 133.0 in/mile and less than 177.0 in/mile.

Number of lots within the range					
2006 Range	0.1 mile	%	0.5 mile	%	264 ft sliding base length
<=51.0	117	39.4%	260	43.8%	42.3%
51.1 to 61.0	84	28.3%	142	23.9%	25.2%
61.1 to 76.0	68	22.9%	128	21.6%	21.9%
76.1 to 81.0	7	2.4%	20	3.4%	3.5%
81.1 to 91.0	16	5.4%	17	2.9%	3.4%
>=91.1	5	1.7%	26	4.4%	3.7%
Total	297	100.0%	593	100.0%	100.0%

Table 19 – Percentage of lots within a lot size range.

Incentive / Disincentive			
Lane	0.1 mile	0.05 mile	264' Sliding
WB	\$9,000	\$10,225	\$9,794
EB	\$10,000	\$11,575	\$10,990
Total	\$19,000	\$21,800	\$20,783

Table 20 – Incentive / disincentive project totals.

Concrete Pavement Data Analysis

There were two concrete paving projects for the 2006 construction season, project IM-5-094(034)053 and IM-2-094(033)315. IM-5-094(034)053 was the only concrete project to have data collected in 2006. The IM-2-094(033)315 project was completed late in the season and the temperature was too cold to use the lightweight profiler. Tables 21 and 22 are a summary of the RoLine and single point lasers. Also, there is a histogram for the RoLine lasers.

Difference between lasers			
	Point	RoLine	Difference
Average	57.2	42.3	14.9
stdev	7.3	8.6	6.1
min	47.5	24.9	5.1
max	76.0	65.4	24.4

Table 21 – Summary of data collected with Point and RoLine lasers. - IM-5-094(034)053

Number of lots within the range		
IRI Range	0.1 Mile	%
<=30.0	4	11.1%
30.1 to 35.0	2	5.6%
35.1 to 40.0	6	16.7%
40.1 to 45.0	13	36.1%
45.1 to 50.0	6	16.7%
50.1 to 55.0	1	2.8%
55.1 to 60.0	3	8.3%
60.1 to 65.0	0	0.0%
65.1 to 70.0	1	2.8%
70.1 to 75.0	0	0.0%
75.1 to 80.0	0	0.0%
>=80.1	0	0.0%
Total	36	100%

Table 22 – Histogram of data collected with RoLine lasers. - IM-5-094(034)053

A large difference between the RoLine and point lasers IRI measurements exists. This is due to the longitudinal tinning on the concrete. The point lasers fall between the peaks and valleys of the longitudinal tinning. As the lasers fall between the peaks and valleys the accumulated IRI develops a false IRI score for the roadway.

Summary

The data collected with LWP has used 3 people to operate the equipment. That will change to 2 people when the pilot vehicle is eliminated from the profiling train. The pilot vehicle seems to cause problems with cars trying to pass the vehicle train. Removing the pilot vehicle will reduce the average man hours required per project. The average time to profile is 4 minutes per lane mile. The setup and breakdown of the LWP take approximately one half hour each to complete. The setup and breakdown include the mounting of the laptop and lasers on the LWP, calibrating the LWP, and setting start and stop cones.

The maintenance requirements completed for the LWP can be seen in the table below.

Maintenance Requirements
Oil and filter change at 44.4 hours
Oil and filter change, lube, checked drive belt tension, and rotated front tires at 97.0 hours
Oil and filter change, lube, checked drive belt tension, and rotated front tires at 150.0 hours
Oil and filter change, lube, checked drive belt tension, and replaced front tires at 200.0 hours

With the HSP projects are profiled at 55 mph unless the speed limit prohibits this speed, to which the project will be profiled at or below the posted speed limit. The average time to profile on a project is approximately one minute per mile. It takes approximately 30 minutes apiece to setup and takedown the HSP. With one operator needed to profile a project one man hour is required to setup and breakdown the LWP.

The HBP data was analyzed by using a histogram of the existing SP for each type of project. Also, it was analyzed by determining the incentive / disincentive for the project using 0.1 mile lot, 0.05 mile lot, and a 264' sliding lot. The histogram data can be used as historical data to compare with previous years of profile data collection.

Ideally the percent of lots with a lower IRI would increase with the contractors trying to improve the ride for a larger incentive. The charts below are the summary of the 2006 projects. The second year of data collection had an increase in the number of lots in the lower IRI brackets except in mine and blend projects.

Mine and Blend

Range (in/mile)	2005		2006	
	0.1 Mile Lots	%	0.1 Mile Lots	%
<=32.0	62	26.5%	201	22.7%
32.1 to 36.0	87	37.2%	224	25.3%
36.1 to 39.0	35	15.0%	132	14.9%
39.1 to 42.0	18	7.7%	89	10.1%
42.1 to 50.0	25	10.7%	165	18.7%
50.1 to 57.0	4	1.7%	43	4.9%
57.1 to 64.0	1	0.4%	19	2.1%
64.1 to 70.0	1	0.4%	9	1.0%
>=70.1	1	0.4%	2	0.2%
Total	234	100.0%	884	100.0%

Table 23 – Histogram summary of mine and blend projects in 2006.

Structural Overlay

Range (in/mile)	2005		2006	
	0.1 Mile Lots	%	0.1 Mile Lots	%
<=34.0	35	3.4%	52	11.5%
34.1 to 39.0	140	13.8%	70	15.4%
39.1 to 44.0	244	24.0%	94	20.7%
44.1 to 48.0	152	14.9%	79	17.4%
48.1 to 56.0	243	23.9%	103	22.7%
56.1 to 62.0	97	9.5%	34	7.5%
62.1 to 69.0	55	5.4%	16	3.5%
69.1 to 75.0	23	2.3%	5	1.1%
>=75.1	29	2.8%	1	0.2%
Total	1018	100.0%	454	100.0%

Table 24 – Histogram summary of Structural Overlay projects in 2006.

Thin Lift Overlay < 133

Range (in/mile)	2005		2006	
	0.1 Mile Lots	%	0.1 Mile Lots	%
<=47.0	911	53.1%	228	72.2%
47.1 to 57.0	483	28.1%	50	15.8%
57.1 to 67.0	214	12.5%	21	6.6%
67.1 to 72.0	45	2.6%	5	1.6%
72.1 to 82.0	38	2.2%	8	2.5%
>=82.1	26	1.5%	4	1.3%
Total	1717	100.0%	316	100.0%

Table 25 – Histogram summary of Thin Lift projects in 2006.

Thin Lift Overlay > 133

Range (in/mile)	2005		2006	
	0.1 Mile Lots	%	0.1 Mile Lots	%
<=47.0	2	0.6%	213	36.4%
47.1 to 57.0	39	12.5%	219	37.4%
57.1 to 67.0	94	30.0%	121	20.7%
67.1 to 72.0	50	16.0%	9	1.5%
72.1 to 82.0	75	24.0%	18	3.1%
>=82.1	53	16.9%	5	0.9%
Total	313	100.0%	585	100.0%

Table 26 – Histogram summary of Thin Lift projects in 2006.

The data was analyzed using the incentives / disincentives with 0.1 mile lot, 0.05 mile lot, and 264' sliding continuous reporting. This was done to determine the best way to analyze the data collected for a paving project. There is not a large difference between the different methods of analyzing the data. The data for mine and blend, structural overlay, thin lift with initial IRI >133, and thin lift with initial IRI < 133 was broken down to the price per mile for each method of analysis. These can be seen in the charts below.

Mine and Blend

Lot Size	AC-NH-7-002(062)065		AC-NH-7-002(064)077		SER-3-019(039)135		HPP-4-052(038)068		SER-3-281(084)905		Average Incentive/mile
	Incentive	Incentive/mile	Incentive	Incentive/mile	Incentive	Incentive/mile	Incentive	Incentive/mile	Incentive	Incentive/mile	
0.1	\$50,200	\$4,204	\$37,000	\$3,099	\$5,800	\$1,758	\$49,425	\$3,901	\$12,300	\$3,220	\$3,236
0.5	\$52,350	\$4,384	\$38,600	\$3,233	\$7,350	\$2,227	\$49,275	\$3,889	\$12,500	\$3,272	\$3,401
264' Sliding	\$52,302	\$4,380	\$38,714	\$3,242	\$7,499	\$2,272	\$49,137	\$3,878	\$12,526	\$3,279	\$3,410

Table 27 – Incentive paid for Mine and Blend.

Structural Overlay

Lot Size	NH-6-002(072)341		IM-2-094(060)295		Average Incentive/mile
	Incentive	Incentive/mile	Incentive	Incentive/mile	
0.1 mile	\$25,650	\$1,982	\$21,150	\$2,084	\$2,033
0.5 Mile	\$27,338	\$2,113	\$22,538	\$2,220	\$2,167
264' Sliding	\$28,043	\$2,167	\$22,268	\$2,194	\$2,181

Table 28 – Incentive paid for Structural Overlays.

Thin Lift Overlay Initial IRI > 133

Lot Size	NH-6-002(072)341		IM-2-094(060)295		Average Incentive/mile
	Incentive	Incentive/mile	Incentive	Incentive/mile	
0.1	\$20,750	\$1,434	\$19,000	\$1,257	\$1,345
0.5	\$21,500	\$1,486	\$21,800	\$1,442	\$1,464
264' Sliding	\$21,169	\$1,463	\$20,783	\$1,375	\$1,419

Table 29 – Incentive paid for Thin Lift Overlay Initial IRI > 133.

Thin Lift Overlay Initial IRI ≤ 133

Lot Size	NH-6-002(072)341		Average Incentive/mile
	Incentive	Incentive/mile	
0.1	\$35,250	\$2,063	\$2,063
0.5	\$34,750	\$2,033	\$2,033
264' Sliding	\$30,205	\$1,768	\$1,768

Table 30 – Incentive paid for Thin Lift Overlay Initial IRI ≤ 133.

The 0.1 mile lots have the smallest incentive /mile for all of the paving methods

except the thin lift overlay with an initial IRI < 133. The 264' sliding lot and 0.05 mile lot are very similar in their incentive for most of the projects profiled. There is a very small difference between all three methods of analyzing the data.

Due to the small difference in the incentive / disincentive for the existing SP, the 264' continuous sliding lot may be ideal to eliminate lots beginning or ending in the middle of a bump. In the existing SP 0.1 mile lots are used. If a lot does not meet the 0.1 mile lot IRI requirements in the SP the contractor may be required to grind in between the beginning and end locations of the lot to achieve an acceptable IRI.

Only one concrete project was profiled in 2006. There are much fewer concrete paving jobs in North Dakota than HBP paving jobs. This limits the amount of data collected. The one concrete project collected had a longitudinal tined texture. The project was profiled with both the RoLine lasers and single point lasers. This was a good comparison of the effect of the longitudinal tined texture. The average IRI between the two types of lasers was 14.9 inches/mile.

Recommendations

It is recommended not to use the shadow vehicle when profiling a project with the LWP. The shadow vehicle made passing the paving train more difficult. Removing the shadow vehicle will allow passing traffic to pass without being in the other lane as long.

The HSP will profile projects much faster than the LWP. The HSP is recommended to be used when the traffic speeds allow. For areas where the speed limit and geometrics prevent the HSP from being used the LWP will be used.

It is also recommended to use the RoLine lasers for a surface that has longitudinal tining or has been ground. A roadway with the entire surface having a longitudinal tined or ground surface should be profiled with the RoLines lasers. These lasers will provide a more accurate measurement of the IRI.

Appendix A

HBP Pavement Pay Band Schedule

<=32.0	\$ 400.00
32.1 to 36.0	\$ 300.00
36.1 to 39.0	\$ 200.00
39.1 to 42.0	\$ 100.00
42.1 to 50.0	\$ -
50.1 to 57.0	\$(100.00)
57.1 to 64.0	\$(200.00)
64.1 to 70.0	\$(400.00)
>=70.1	CA

Structural Overlay Pay Band Schedule

<=34.0	\$ 300.00
34.1 to 39.0	\$ 225.00
39.1 to 44.0	\$ 150.00
44.1 to 48.0	\$ 75.00
48.1 to 56.0	\$ -
56.1 to 62.0	\$ (75.00)
62.1 to 69.0	\$(150.00)
69.1 to 75.0	\$(300.00)
>=75.1	CA

Thin Lift Overlay Pay Band Schedule

<=47.0	\$ 150.00
47.1 to 57.0	\$ 50.00
57.1 to 67.0	\$ -
67.1 to 72.0	\$ (50.00)
72.1 to 82.0	\$(150.00)
>=82.1	CA
