



Evaluation of the SafeLane™ Overlay System for Crash Reduction on Bridge Deck Surfaces

Minnesota
Department of
Transportation

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John F. Evans, Principal Investigator
Department of Chemistry and Biochemistry
University of Minnesota Duluth

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16. Abstract (Limit: 250 words) <p>The winter performance of the SafeLane™ commercial overlay system has been evaluated at four installations on bridge decks in the state of Minnesota. The study was conducted over a period of a total of three years. Analyses included mechanical and chemical testing of the components, chloride analysis as a function of depth, friction by skid test and visual inspection. At one site plow operator's comments were gathered to assess retention of deicing chemicals from event to event. All sites were included in a comparison of accident frequency before and after overlay installation.</p>			
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Prepared by:

John F. Evans

Department of Chemistry and Biochemistry
University of Minnesota Duluth

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Executive Summary

The efficacy of the SafeLane™ overlay system applied to bridge decks in Minnesota has been evaluated over a three-year period. One installation was studied in detail, while accident rate data from three other installations were included to improve statistics. The primary considerations were: 1) the performance of the overlay as a sealcoat to reduce the ingress of chloride from deicing chemicals applied during the winter season, 2) the performance of the overlay with respect to improved traction resulting in the reduction of accidents and retention of deicing chemicals, and 3) the general integrity of the bonding of the overlay system to the concrete bridge deck.

The following conclusions may be drawn from this study:

- When the surface of the bridge deck is carefully prepared prior to installation a strong, adherent overlay is obtained by the application of the SafeLane™ system.
- Initially the traction afforded by the coarse, rough aggregate is outstanding.
- Evidence of reduced accident rates is found, and it is inferred this can be attributed to improved traction directly and the retention of deicing chemicals indirectly.
- As a sealcoat, the SafeLane™ overlay affords excellent protection against the intrusion of chloride, which would likely decrease corrosion of reinforcing steel over the service life of the bridge deck to which it is applied.
- Significant rapid wear is noted primarily due to plow blade shearing forces, but also from normal traffic in wheel lanes. The observed shearing of the aggregate is consistent with loss of traction as measure by skid testing. Extrapolation of the measured loss in traction predicts that the service life of the overlay is limited to 3.5 – 5 years before remediation is required.

It is recommended that more thorough, longer-term studies be conducted to further evaluate this and other systems.

Chapter 1. Introduction

The Minnesota Department of Transportation (Mn/DOT) has been using anti-icing chemicals since mid 1990's to help prevent frost and ice formation on critical roadway segments and bridge decks. The objective of this research was to evaluate the product performance, safety, and maintenance benefits associated with the Cargill SafeLane™ anti-icing pavement overlay system through field tests. Mobile anti-icing operations require maintenance staff to deploy personnel and equipment to spread winter chemicals. Materials are not always deployed in a timely matter because of rapidly changing weather conditions and limited resources.

Stationary anti-icing systems are another option. A system consists of anti-icing chemicals, spray nozzles, conduit, pumps, storage tanks, weather and pavement sensing equipment, computer software and hardware, and a communication system. The system will automatically apply chemicals based on pre-set criteria, thus reducing the environmental impact. These systems use proprietary software and hardware, and are very expensive to install and maintain.

Mn/DOT is continuously looking for more cost effective and efficient means of dealing with dangerous frost and icy road and bridge conditions. Mn/DOT is also searching into ways and means of preserving bridge decks by ensuring that ingress of deicing salts is minimized or their effects are mitigated.

The Cargill SafeLane™ overlay is claimed to be an anti-icing overlay system that uses a unique aggregate that absorbs and stores liquid deicing chemicals. The anti-icing chemicals are then available to be released to help prevent frost and ice formation.

This report describes the results of a three-year study to provide an evaluation of the effectiveness of the SafeLane™ overlay system as applied to bridge deck(s) with respect to accident reduction, traction and wear performance, reduced maintenance costs and reduced cost of the application of deicing chemicals. Four sites have been studied. The first site was installed through a partnership agreement between Cargill, Inc. and (Mn/DOT). It is located in Hibbing, Minnesota where the SafeLane™ overlay was installed in July 2006 on the southbound lanes of the Mitchell bridges (69002 & 69003), located 3.7 miles south of the junction of Trunk Highway (TH) 73 on TH 169 in St. Louis County. This site was chosen by Mn/DOT based on a history of a high number of crash incidents at this site. For comparison, the uncoated northbound lane served as a comparative control. At the time of installation, a series of laboratory tests were carried out by Mn/DOT on the component materials of this system. This site was the most thoroughly studied.

Three additional SafeLane™ installations were added to the study during the second year, to provide additional accident data in hopes of improving the statistical indicators of the efficacy of this overlay system. The study of these installations was limited to the inclusion of these traffic safety statistics for the winter seasons. These additional installations are briefly described in the table below, as each of these installations is somewhat different.

Table 1.1. Location of SafeLane™ Installations Studied.

Location/Year of Installation/Highway Designation	Type of Installation ¹	Direction of Traffic Flow	Starting Milepost	Ending Milepost
Alexandria (D-4)/ Summer 2007/I-94 over railroad tracks at R.P. 104.2	Deck	EB	104.218	104.256
	Deck	WB	104.255	104.217
Barnsville (D-4)/ Summer 2007/ I-94 over railroad tracks at R.P. 22	Deck	EB	22.026	22.074
	Approach Wheel Lane	WB ²	22.192	22.069
	Deck	WB ²	22.068	22.012
	Exit Wheel Lane	WB ²	22.012	21.555
Bemidji (D-2)/ Summer 2007/ US Hwy 2 at R.P. 112	Deck	EB	112.508	112.562
	Deck Control (No SafeLane™)	WB	112.562	112.508

¹ Types of installation include those with a control lane to which the SafeLane™ was not applied (Bemidji and Hibbing), and those to which this chip-seal was applied to traffic lanes in both directions (Alexandria and Barnsville).

² The Barnsville installation is further distinguished by the additional application of the chip-seal to wheel lane approaches to and exits from the westbound lane. This material was applied into a 3/8" deep ground-in area, one foot off of center line, and is four feet wide in each lane.

Chapter 2. Installation Notes: Hibbing Site

Weather Conditions: The weather was sunny with appreciable wind with a deck temperature ranged 103-105 F on day 1. Day 2 was slightly overcast with less wind and deck temperature that ranged 95-107 F. Air temperature was 70-85 F during the application of the overlay.

Surface Preparation and Related Issues: Deck surface/gutters were prepared by shot-blasting (390 size shot employed), with the exception of epoxy paint stripes that were removed in part by a grinder. This included the removal of 100 x 16 ft area of bituminous overlay. Backpack blowers used to remove dust after shot-blasting, and after sweeping up excess aggregate from course 1. Joints and edges were taped with duct tape.

Two Course Installation of Overlay: Both courses for the passing lane were installed on day 1, and both for the driving lane on day 2. In general, batches of epoxy were mixed as needed to prevent premature curing of the epoxy before it was spread. Epoxy batches were mixed to cover approximately 300 sq. ft. for each course. As noted from the table below, which summarizes rate of preparation, application and epoxy coverage, smaller batches (6.8 gal) were mixed for application in course 1, while larger batches were mixed for the second course (20.2 gal). The consistency of the two part epoxy at these temperatures (~85 F) is “water-like” immediately following mixing. For course 1 the epoxy was squeegeed onto clean deck surface followed by hand application and spreading of aggregate. Curing of course 1 occurred in approximately 3 hrs. Excess aggregate removed following curing using street sweeper equipped with a brush. A single pass was effective in removing/recovering excess aggregate. Dust removed by backpack blower. The second course of epoxy and aggregate was then applied, followed by removal of excess aggregate after curing. Both courses were applied to the first lane before beginning work on the second lane.

Table 2.1. Summary Details for Hibbing Installation.

Lane	Activity	Rate, sq. ft./h	Epoxy Coverage, gal./100 sq. ft.
Day One: Passing Lane	Surface Preparation	1552	
	Course 1 Application	3372	
	Course 1 Epoxy Coverage		2.2 – 2.3
	Course 2 Application	2511	
	Course 2 Epoxy Coverage		7.5 – 8.1
	Overall Preparation and Application	7435	

Lane	Activity	Rate, sq. ft./h	Coverage, gal./100 sq. ft.
	Overall Epoxy Coverage		9.7 – 10.2
Day Two: Driving Lane	Surface Preparation	1971	
	Course 1 Application	3808	
	Course 1 Epoxy Coverage		2.0 – 2.1
	Course 2 Application	2929	
	Course 2 Epoxy Coverage		7.1 – 7.6
	Overall Preparation and Application	8708	
	Overall Epoxy Coverage		9.1 – 9.7
Averages	Surface Preparation	1760	
	Course 1 Application	3590	
	Course 1 Epoxy Coverage		2.0 – 2.3
	Course 2 Application	2720	
	Course 2 Epoxy Coverage		7.1 – 8.1
	Overall Preparation and Application	8072	
	Overall Epoxy Coverage		9.1 – 10.2

Note: Rates do not include beak time or down time awaiting aggregate delivery. For each course an epoxy batch covers approx. 300 sq. ft.

Table 2.2. Cost Breakdown for Hibbing Installation.

Item	Cost	Notes
Traffic Control		
Mn/DOT (labor)	\$6,165.00	
United Rental (Invoice for set-up and takedown)	\$7,370.00	
<i>Sub-Total</i>	\$13,535.00	
Shotblasting Deck		
PCI, Incorporated	\$7,134.75	
<i>Sub-Total</i>	\$7,134.75	
Materials		
Cargill (Epoxy and Aggregate)	\$46,980.00	
Mn/DOT (misc. tools, supplies, etc)	\$1,463.00	
<i>Sub-Total</i>	\$48,443.00	
Application of Product		
Mn/DOT (labor, includes supervision)	\$15,605.00	432 regular hours plus 178.5 overtime hours.
Mn/DOT (equipment)	\$10,730.00	
<i>Sub-Total</i>	\$26,335.00	
Striping		
Head of the Lakes (after overlay)	\$600.00	
<i>Sub-Total</i>	\$600.00	
<i>Grand Total</i>	\$96,047.75	
<i>Square Feet Completed</i>	16,590	
<i>Unit Price/Square Foot</i>	\$5.79	

Chapter 3. Materials Characterization

Laboratory tests on aggregate and epoxy were performed by Bernard I. Izevbekhai, P.E., Mn/DOT Office of Materials and Roads Research.

FT-IR of Epoxy Components:

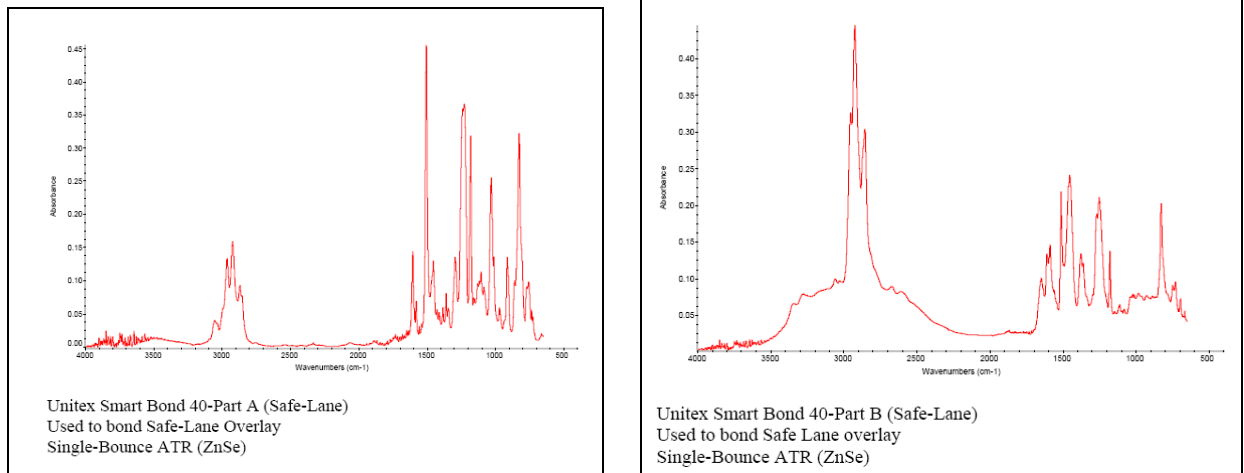


Figure 3.1. Attenuated total reflectance infrared spectra of epoxy components.

Bonding Test: This test examines the adherence of epoxy-bound Cargill SafeLane™ Aggregate System to concrete through a modified ACI R 503 - 93 procedure for evaluating bonding. It also elucidates the failure modes, but does not predict performance in service. This procedure does not produce results comparable to the ASTM C-882 procedure due to difference in the loading configuration.

During installation of the SafeLane™ system on the Mitchell Bridges (Hibbing, MN) aggregate and epoxy samples were obtained and tested for quality. As the overlay system cured it became necessary to obtain cores and evaluate the bonding of the epoxy system. The prescribed test for bond evaluation is the ASTM C-882 procedure, known as the slant shear test. Because a simulation of the substrate-overlay-substrate system is not feasible by coring, bond specimens were prepared in the lab.

An alternative evaluation procedure was, therefore, sought and the following were employed:

- Mn/DOT Spec 3723 modified to emphasize bond strength in lieu of elongation and sample geometry for the pullout test equipment.
- ACI 503 R-93 ,

A 1 to 1 mixture of the two part epoxy was made, aggregate added, and the sample placed in the designated standard mold. These molds are fabricated by cutting concrete of a minimum compressive strength of 4000 psi to 1.5 x 3 x 2” dimensions. The SafeLane™ mixture was placed in the mold between the blocks and tamped gently until there was no noticeable volume change. Three samples were prepared and cured at room temperature.

The test specimen was placed in the standard housing and the grip of the bond pull out machine (Fig. 3.2) and pulled out at a loading rate equivalent to a deformation rate of 0.1 inch/min until the maximum load was attained.



Figure 3.2. Pull out machine employed.

As shown in the following figure, bond rupture was observed at the SafeLane™ - concrete interface.

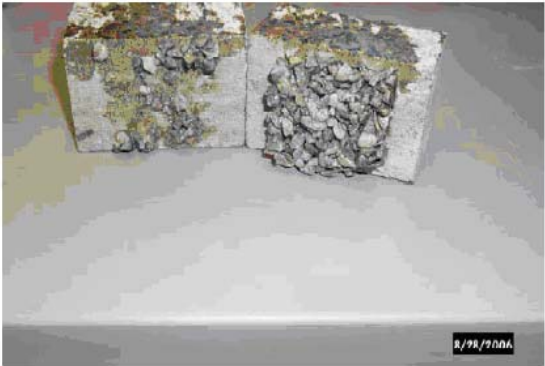


Figure 3.3. Failure of bonding.

Specimen 1 (7 day strength) failed mainly by de-bonding at the interface. Specimen 2 (7 day strength not shown) failed by a combination of de-bonding and tension within the overlay in the overlay. Specimen 3 (28 day strength) failed by de-bonding. Failure loads are shown in the following table.

Table 3.1. Results of the ACI 503 test.

Specimen	Age (days)	Peak Load (lb)	Displacement at Failure (in)	Strain at Failure	Bond Strength psi	Failure Mode
1	7	64.5	0.075	0.15	16.1	De-bonding
2	7	100.0	0.138	0.28	25.0	Bond and Tension
3	28	126.0	0.100	0.20	31.5	De-bonding

The tests above do not have a published reference with which one can compare results. Compared to bond strength requirements of ASTM C-882, which is a different procedure, these results are low.

It should be noted that no significant de-bonding in the field has been observed; see Chapter 4.

Chapter 4. Seal Coat Evaluation: Hibbing Site

In this chapter we focus on the mechanical performance of the SafeLane™ overlay system with regard to bonding to the deck and sealing of it, as examined by visual inspection (reflective crack mapping and photographic documentation) and core sampling to assess the protection provided against chloride intrusion. The following chapter will summarize observations relating to the mechanical performance as manifested in traction performance.

Unfortunately, this installation was made on a deck that had been in service for some time, so that there was significant chloride content already present in the deck. Figure 4.1 shows the pre-installation water and acid soluble chloride profile for the southbound lanes. The data were subjected to statistical analysis, and plotted as a function of depth for the six samples. The error bars give a 95% confidence level for each depth for each type of analysis. Because both the water and acid soluble data have similar depth dependencies, yet the values for the latter are larger, further comparisons have been limited to the results for acid soluble chloride.

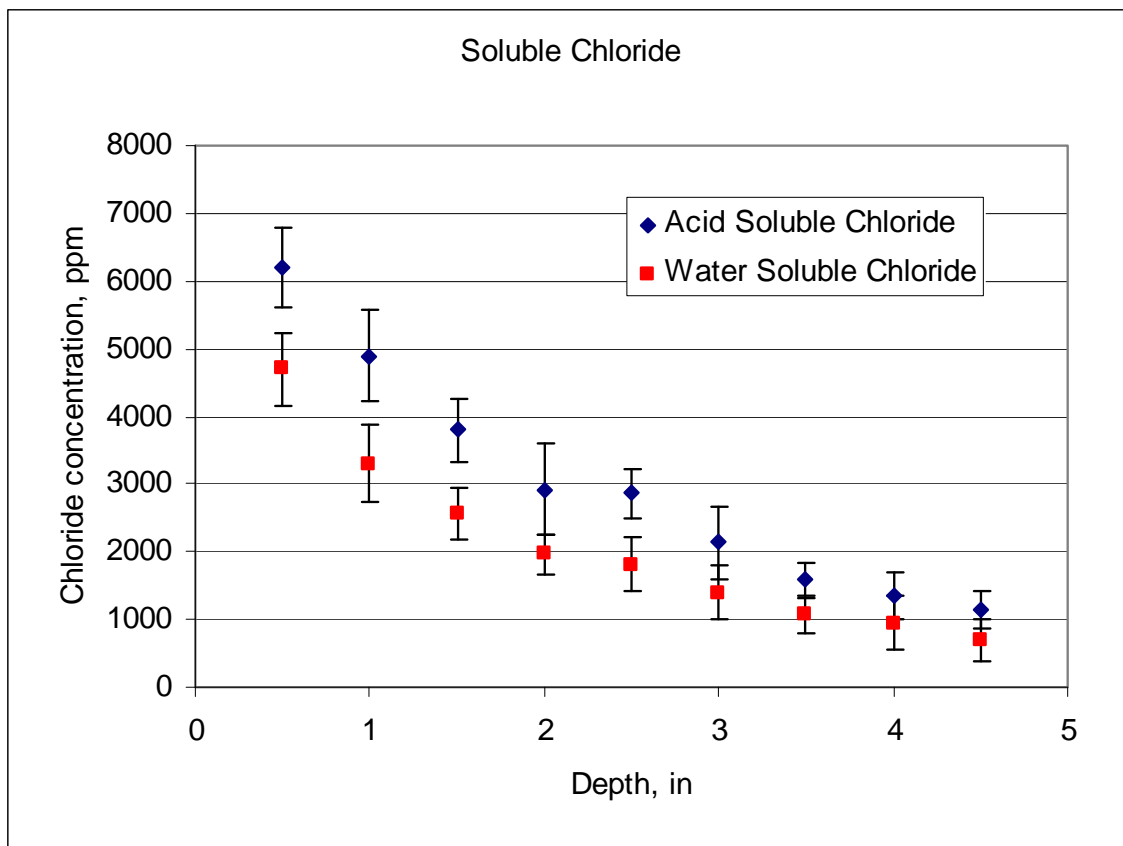


Figure 4.1. Pre-installation chloride concentration variation with depth, southbound lanes. Error bars are at the 95% confidence level for six samples taken at each depth.

Figure 4.2 compares the acid soluble chloride for the SafeLane™ installation (southbound lanes) to that from the northbound control lanes (no overlay) for core samples taken two years after installation. Clearly, the SafeLane™ overlay has provided significant protection against chloride intrusion on the southbound decks.

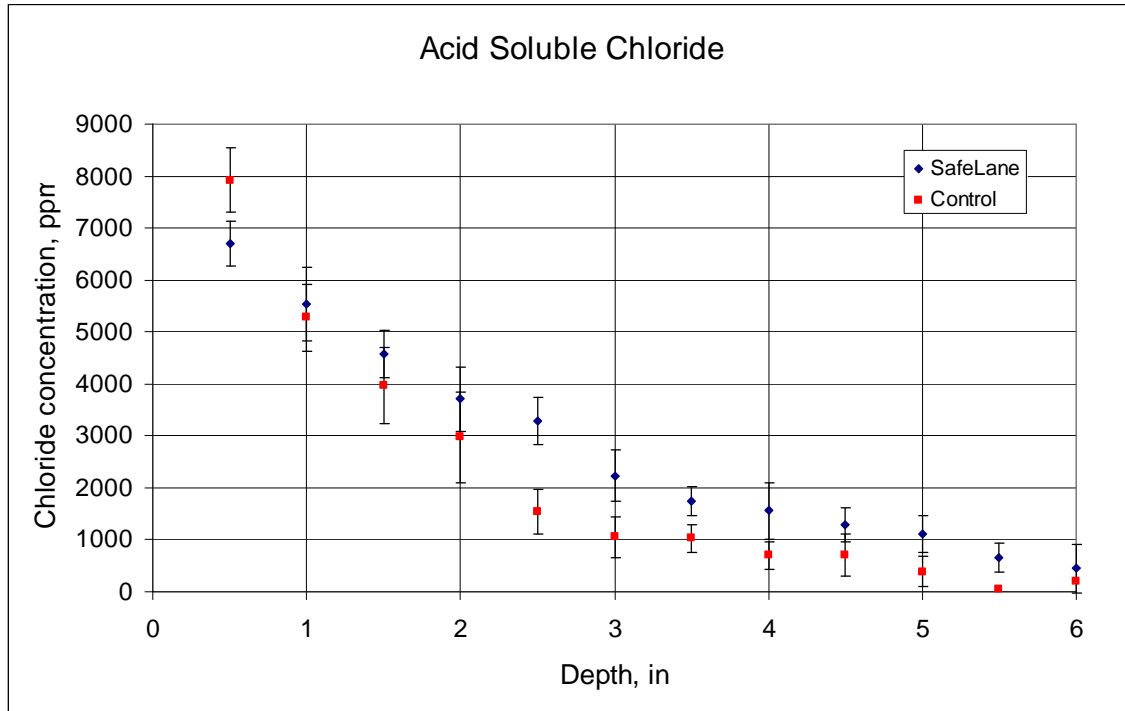


Figure 4.2. Comparison of SafeLane™ (southbound) and control (northbound) lanes for acid soluble chloride content as a function of depth two years after installation (2008). Error bars are at the 95% confidence level for nine samples taken at each depth.

The plot on the following page (Fig. 4.3) shows a comparison of the acid soluble chloride data for pre-installation (2006), after two years of service (2008), and after three years of service life (2009). There are no statistically significant differences between these data sets, further confirming the efficacy of the SafeLane™ overlay from the perspective of its performance as a sealcoat.

More qualitative observations of the sealcoat performance of the SafeLane™ overlay at this site are consistent with the performance inferred from the chloride data presented above. In general the lanes were found to be almost crack-free throughout the three-year span of this study (Fig. 4.4). Bonding integrity for this time span was outstanding with evidence of de-bonding found only at expansion joints that experienced extreme plow shear forces (Fig. 4.5), and one area where the overlay was placed over top of an asphalt repair patch (Fig. 4.6). However, it should be noted that the manufacturer recommends this overlay not be used over asphalt.

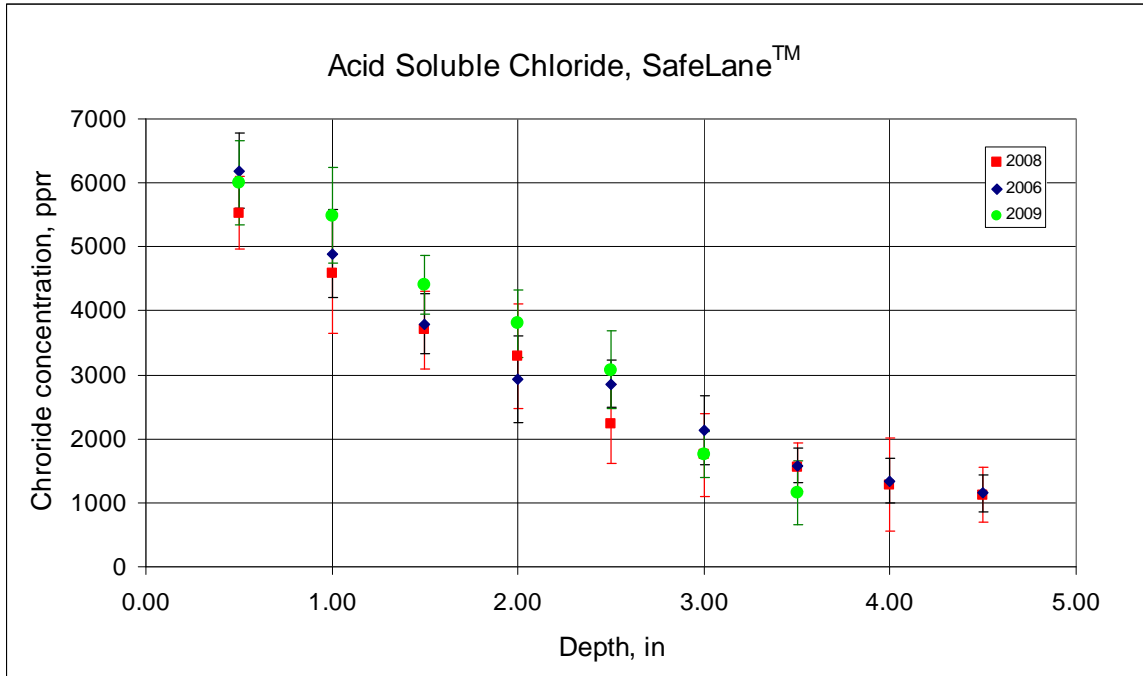


Figure 4.3. Comparison of pre-installation (2006) and post-installation (2008, 2009) chloride concentration profiles. Error bars are at the 95% confidence levels. Data sets ranged in size from three samples to nine samples at each depth.



Figure 4.4. Photographs showing general overall integrity of the Hibbing SafeLane™ installation after two years (left: September, 2008) and three years (right: July, 2009).



Figure 4.5. De-bonding at an expansion joint.



Figure 4.6. De-bonding over an asphalt repair patch.

Core samples taken for chloride analyses all showed excellent bonding between the concrete and the overlay as typified by the photograph shown below (fig 4.7).



Figure 4.7. Photograph of core sample taken in September 2008. Location was at the edge of installation; outside of travel lane

Chapter 5. Traction Measurements: Hibbing Site

Although the integrity of the bonding of this overlay system to the concrete surface of the bridge deck on which it was installed was found to be excellent, as discussed in the previous chapter, other aspects of the mechanical performance of the system were less than satisfactory. These relate to wear observed in both the wheel lanes and the overall surface that were attributed to normal traffic and plowing. The plows used for winter maintenance all use significant down-force on the blades. Both contributed to significant shearing as shown in the photos below.

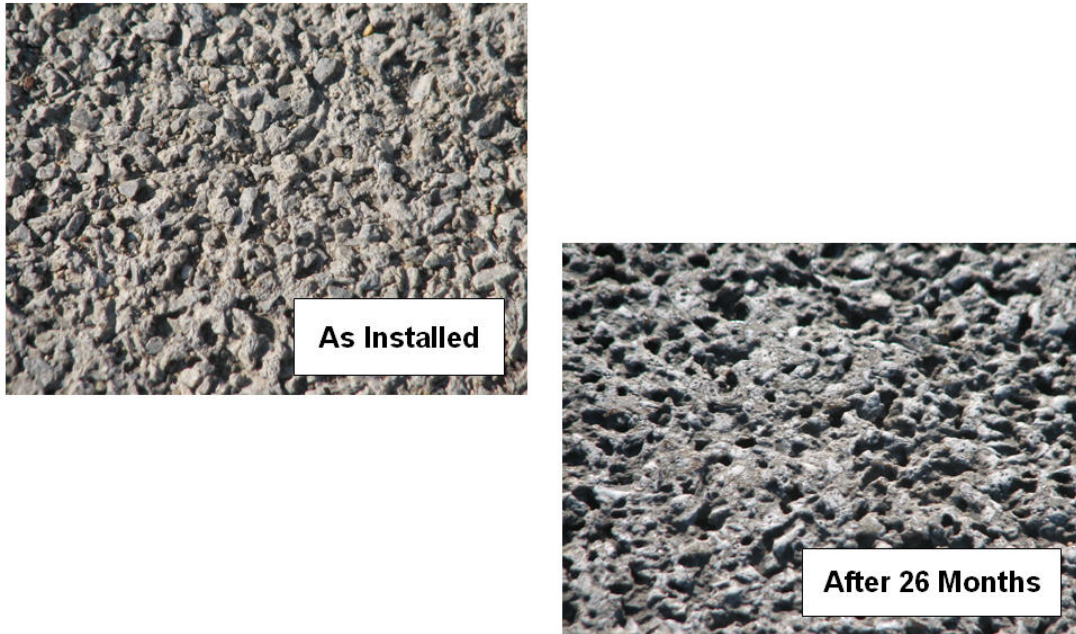


Figure 5.1. Photographs showing surface wear after two winters. Areas shown are approximately 4 x 6 inches.

The wear seemed in large part to be attributable to shearing of the aggregate and epoxy (above right). There was little, if any evidence of the aggregate being pulled out of the epoxy sealcoat, rather the surface appeared to have been milled after the first two winters, and more extensively so after the third. The consequences of this wear are twofold. Firstly there is a reduction of interstitial depressions between the aggregate pieces, which leaves less area to trap deicing chemicals between winter storms or icing “events”. Secondly, there is a significant reduction in traction as the surface wears. Both of these are expected to contribute adversely to performance from a traffic safety perspective.

The observations discussed above can be quantified as they relate to traffic safety by skid testing. Not surprisingly, the surface of the overlay system affords extremely good traction immediately following installation. Unfortunately, plowing in particular degrades traction performance rather dramatically, as would be predicted from the observations discussed above.

Skid tests were performed on the overlay installed at the Hibbing site using the KJ Law skid trailer (Figure 6.1) over the course of three years. The results are plotted in Figure 6.2.



Figure 5.2. KJ Law (Dynatest) skid trailer.

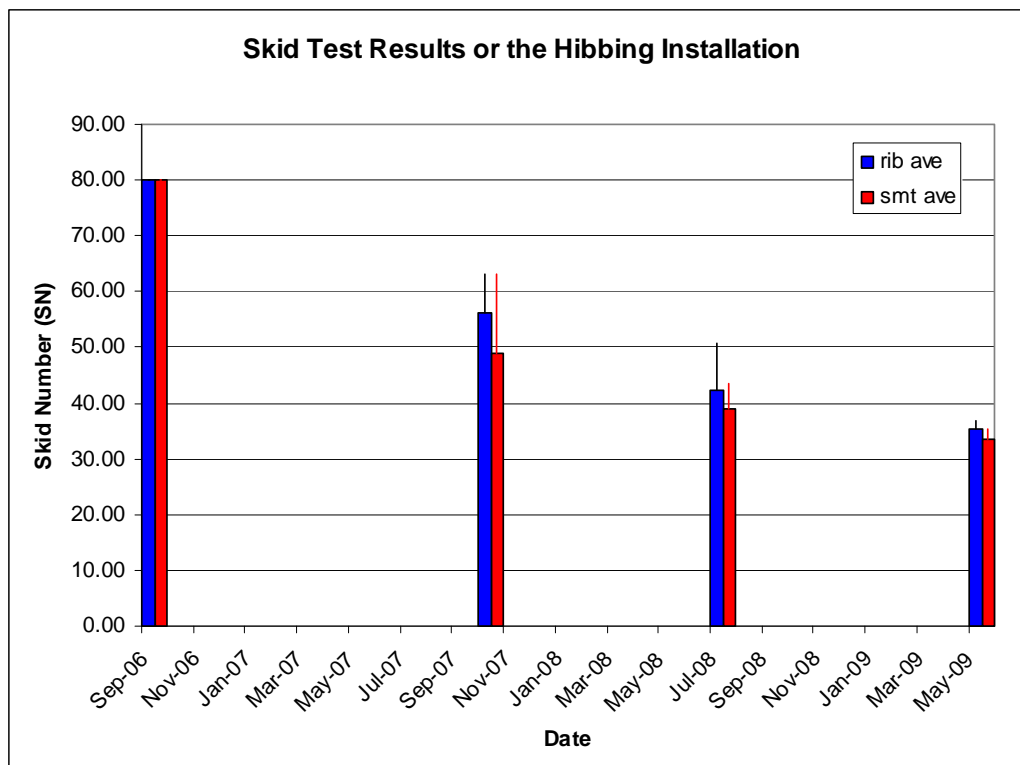


Figure 5.3. Skid test results for the Hibbing site. Error bars are at the 95% confidence level.

The data taken shortly after installation (9/06) is a minimum estimate provided by the operator. The traction was so good that the skid trailer would not skid for either tire type (ribbed vs smooth). This excellent initial performance degraded rather significantly after the first winter,

and continued to decline afterwards. These data are consistent with the qualitative observations discussed earlier.

Using the data from Figure 6.2, exponential decay functions were fit to the data. A least squares fit to the ribbed tire data yielded a correlation coefficient of 0.9908, while that for the smooth tire data gave a value of 0.9640. In each case the regression equation was used to predict the time a value of 15 would be expected for a smooth tire, and likewise a value of 25 for a ribbed tire, giving a value of 3.6 years for the ribbed tire data, and a value of 5.0 years for the smooth tire data. Unfortunately, either of these predictions suggests an unacceptably short service life for the overlay system.

Chapter 6. Retention of Deicing Chemicals: Hibbing Site

In an effort to assess the ability of the overlay to retain deicing chemicals, plow operators were asked to fill out forms which summarized their observations of SafeLane™ performance by comparisons of road surface conditions for the southbound (SafeLane™) vs northbound (no overlay). The form used is reproduced in Appendix A.

Summary of Plow Operators' Observations and Comments for the 2006-7 Season: It should be noted that this winter season was relatively mild, with few major storm events on which to base conclusions. From the 49 reports filed by plow operators the following conclusions may be drawn in light of these observations. Firstly, only 1 report indicated a noticeable difference in the behavior of the test vs control lanes. Ironically, the observation was that the northbound lane (control) was wet during a frost event, while the southbound (SafeLane test) was frost-covered (12/4/06). Many of the operator reports had no comments comparing lanes, and for the dozen which did have comments, statements consistently indicated no difference in behavior of traction or ice/snow management under a variety of conditions (frost, snow, compacted snow, freezing drizzle, ice).

Summary of Plow Operators' Observations and Comments for the 2007-8 Season: All of the 52 reports filed indicate the same conditions for both the northbound and the southbound lanes. Very few provided comments, and for those reports containing comments; these were vague and inconclusive with respect to differentiation of chemical retention or surface conditions for south vs northbound lanes.

Summary of Plow Operators' Observations and Comments for the 2008-9 Season: Only 11 reports were received. One of these reports suggests that the southbound lane was in “worse shape” than the northbound lane. Another reports frost on the northbound lanes, but wet conditions on the southbound lanes. The rest report no differences.

Chapter 7. Accident Reduction: All Sites

The most important potential benefit from the application of an overlay system such as SafeLane™ is improvement in traffic safety at the installation site. Improvement in traction can result from the presence of rougher edges of the exposed aggregate imbedded in the sealcoat, and/or the retention of deicing chemicals within the regions between aggregate particles. Indeed, for the Hibbing installation, during the first winter season following installation no accidents were reported, compared to 3, 4 and 7 accidents attributable to poor winter traction during the preceding three winters. By contrast the number of accidents in the uncoated northbound lanes totaled 8 during that same season. The winter accident rate data (1 October – 30 April) for all four installations for the three years preceding installation through the 2008-9 season are tabulated in Appendix B. In general, for all sites, the *winter accident rate decreased* following the installation of the SafeLane™ as summarized in the following figure.

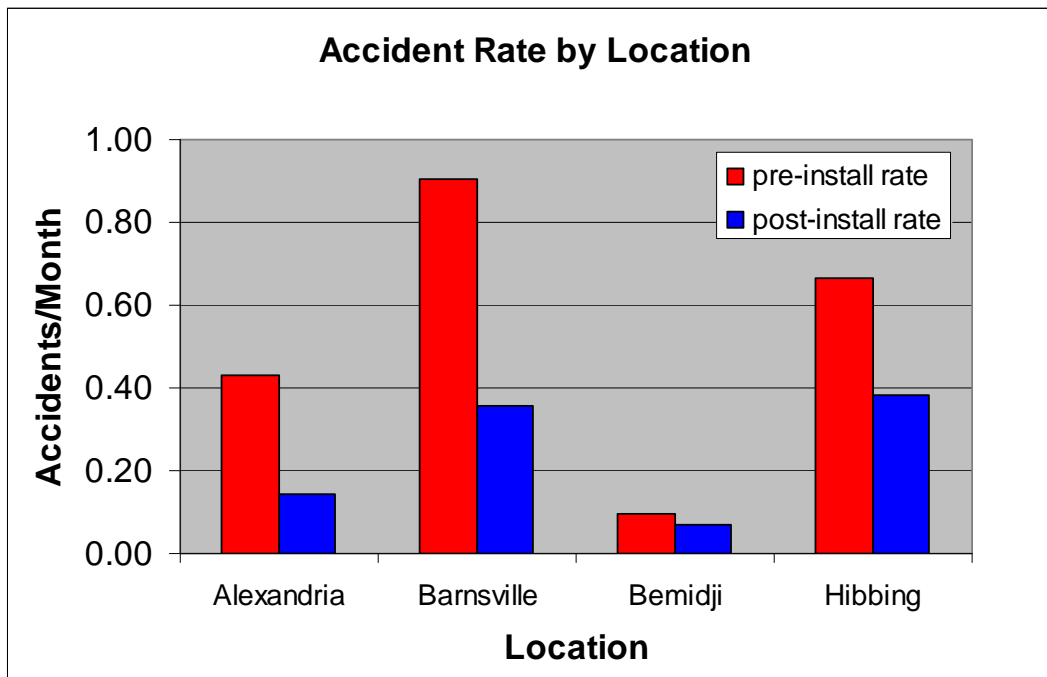


Figure 7.1. Summary of accident rate data by location. Year specific data provided in Appendix B.

Chapter 8. Conclusions and Recommendations

The following conclusions may be drawn from this study:

- When the surface of the bridge deck is carefully prepared prior to installation a strong, adherent overlay is obtained by the application of the SafeLane™ system.
- Initially the traction afforded by the coarse, rough aggregate is outstanding.
- Evidence of reduced accident rates is found, and it is inferred this can be attributed to improved traction directly and the retention of deicing chemicals indirectly.
- As a sealcoat, the SafeLane™ overlay affords excellent protection against the intrusion of chloride, which would likely decrease corrosion of reinforcing steel over the service life of the bridge deck to which it is applied.
- Significant, rapid wear is noted primarily due to plow blade shearing forces, but also from normal traffic in the wheel lanes. The observed shearing of the aggregate is consistent with loss of traction as measure by skid testing. Extrapolation of the measured loss in traction predicts that the service life of the overlay is limited to 3.5 – 5 years before remediation is required.

The term of this study is too short. It is recommended that this overlay system be subjected to more long-term studies to determine if the short service life predicted above is correct. Other overlay systems that utilize aggregates that are less susceptible to ablation by plow blade shearing should also be evaluated for comparison.

Appendix A
Plow Operator's Field Data Collection Form

Mn/Dot Cargill "Safelane" Project
Field Data Collection Form
 Winter 2005-2006

Location: ISTH 535 Ramp from Superior Wi to Minnesota (see enclosed map)

Evaluator's Name _____ **Phone** () _____ **Date** _____ **Time** _____ AM / PM

This form should be completed each time a project evaluator passes through the test section.
 If some information is unknown, leave it blank or use a "?" Do not feel compelled to seek out
 Answers to questions you cannot answer on your own.

RETURN THIS FORM TO:
 Jeff Hall
 Mn/Dot Duluth HQ
 1123 Mesaba Avenue
 Duluth, MN 55811
 Fax: 218-723-4874

1. Reason for Inspection:

Anti-Icing
 Forecasted event
 During storm patrol
 After storm patrol
 Other _____

2. Temperature:

Pavement: _____ °F
 Air: _____ °F

3. Precipitation (Currently):

None
 Rain
 Freezing Rain
 Flurries
 Sleet
 Snow
 Normal
 Wet
 Dry (Powder)

Depth: _____ inches

4. Latest Snow Removal Operation (During this storm):

Type:

None
 Plowing
 Deicing
 Anti-Icing

Status:

Ongoing
 Completed

5. Chemicals Applied:

A. Applications to Test Site:

None
 Solid Chemicals
 # of applications: _____
 Rate _____ lbs/lane-mile
 Liquid:
 # of applications: _____
 Rate _____ gal/lane-mile

6. Traction Conditions (In wheel path):

	Test Site
1. Not tested	<input type="checkbox"/>
2. Not slippery	<input type="checkbox"/>
3. Tires slip, then grip	<input type="checkbox"/>
4. Tires slide on braking	<input type="checkbox"/>

7. Roadway Condition:

A. Wheelpath Areas:

	NBL Site	SBL Site
1. Clear-Dry	<input type="checkbox"/>	<input type="checkbox"/>
2. Clear-Wet	<input type="checkbox"/>	<input type="checkbox"/>
3. Slush	<input type="checkbox"/>	<input type="checkbox"/>
4. Frost	<input type="checkbox"/>	<input type="checkbox"/>
5. Ice	<input type="checkbox"/>	<input type="checkbox"/>
6. Compacted Snow	<input type="checkbox"/>	<input type="checkbox"/>
7. Snow or Ice Thickness _____ (inches)		
8. % Covered, snow/ice _____		
9. Bonded to Pavement? _____ (Y, N or ?)		

B. NON- Wheelpath Areas:

	Test Site	Control Site
1. Clear-Dry	<input type="checkbox"/>	<input type="checkbox"/>
2. Clear-Wet	<input type="checkbox"/>	<input type="checkbox"/>
3. Slush	<input type="checkbox"/>	<input type="checkbox"/>
4. Frost	<input type="checkbox"/>	<input type="checkbox"/>
5. Ice	<input type="checkbox"/>	<input type="checkbox"/>
6. Compacted Snow	<input type="checkbox"/>	<input type="checkbox"/>
7. Snow or Ice Thickness _____ (inches)		
8. % Covered, snow/ice _____		
9. Bonded to Pavement? _____ (Y, N or ?)		

8. COMMENTS

Photo Available? YES (Attach) NO

Appendix B

Accident Rates for the Installations under Study^{*}

^{*} Accident rates are accidents/month. For all tables the shaded rows correspond to SafeLane™ installations. In each case data were tabulated for the length of the bridge lanes plus 0.1 mile before the start of the bridge and 0.1 mile after the end of the bridge. A winter season was considered to begin on 1 October of a given year and end on 30 April of the following year. Only accidents which were reported for poor road surface conditions (e.g. wet, snow, ice, freezing rain, frost, etc.) were included.

Hibbing D-1				
Season	Direction	Total	Injury or death	Property
<i>Pre-install</i>				
2003-4 N	north	0.29	0.14	0.14
2003-4 S	south	0.43	0.14	0.29
2004-5 N	north	0	0	0
2004-5 S	south	0.57	0.14	0.43
2005-6 N	north	0.29	0	0.29
2005-6 S	south	1.00	0.29	0.71
<i>Post-install</i>				
2006-7 N	north	1.14	0.14	1.00
2006-7 S	south	0	0	0
2007-8 N	north	0.29	0	0.29
2007-8 S	south	0.57	0	0.57
2008-9 N	north	0.14	0	0.14
2008-9 S	south	0.57	0	0.57

Bemidji D-2				
Season	Direction	Total	Injury or death	Property
<i>Pre-install</i>				
2004-5 E	east	0.14	0	0.14
2004-5 W	west	0	0	0
2005-6 E	east	0.14	0	0.14
2005-6 W	west	0.14	0	0.14
2006-7 E	east	0	0	0
2006-7 W	west	0.14	0	0.14
<i>Post-install</i>				
2007-8 E	east	0	0	0
2007-8 W	west	0.14	0.14	0
2008-9 E	east	0.43	0.14	0.29
2008-9 W	west	0	0	0

Alexandria D-4				
Season	Direction	Total	Injury or death	Property
<i>Pre-install</i>				
2004-5 E	east	0.29	0	0.29
2004-5 W	west	0	0	0
2005-6 E	east	0.14	0	0.14
2005-6 W	west	0.71	0.29	0.43
2006-7 E	east	0	0	0
2006-7 W	west	0.14	0	0.14
<i>Post-install</i>				
2007-8 E	east	0.14	0	0.14
2007-8 W	west	0	0	0
2008-9 E	east	0.14	0	0.14
2008-9 W	west	0.29	0.14	0.14

Barnsville D-4				
Season	Direction	Total	Injury or death	Property
<i>Pre-install</i>				
2004-5 E	east	0.29	0.14	0.14
2004-5 W	west	0.57	0.14	0.43
2005-6 E	east	0.86	0.14	0.71
2005-6 W	west	0.71	0	0.71
2006-7 E	east	0	0	0
2006-7 W	west	0.29	0.14	0.14
<i>Post-install</i>				
2007-8 E	east	0	0	0
2007-8 W	west	0.29	0	0.29
2008-9 E	east	0.14	0	0.14
2008-9 W	west	0.29	0	0.29