

Cargill "Safe Lane"

Anti Icing Overlay System

Progress Report #4

2003-2004 Through 2006-2007 Winter Seasons



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**CARGILL “SAFE LANE”
ANTI-ICING OVERLAY SYSTEM PROGRESS REPORT # 4
(2003-2004 through 2006-2007 Winter Seasons)**

I. Introduction

State Department of Transportations (D.O.T.) has used the proactive, anti-icing technique for winter maintenance since the mid-1990’s to prevent the bonding of frost, ice, or snow to pavements or bridge decks. Mobile anti-icing operations are now in use in all snow states in the United States. D.O.T.’s are now researching methods and materials to improve the use of the anti-icing technology. Fixed, automated system technology (F.A.S.T.) has also been in use in the United States since the mid-1990’s. F.A.S.T. systems incorporate a system of nozzles, supply piping, pumps, and control systems that are permanently attached to bridges or pavement sections. A new anti-icing technology was brought to the attention of the Wisconsin D.O.T. Winter Operation Unit in 2002. This technology incorporates an epoxy and aggregate system that functions as an anti-icing overlay for concrete bridges decks or concrete pavement sections. Section II of this progress report further describes the anti-icing overlay technology.

II. Description of Anti-Icing Overlay System

The anti-icing overlay consists of a thin layer of epoxy spread over a bridge deck or pavement surface and a layer of an absorptive aggregate spread over the surface of the wet epoxy. After the epoxy has hardened, a liquid anti-icing material such as salt brine or magnesium chloride (MgCl₂) can be applied to the overlay surface and allowed to soak into the aggregate layer. The aggregate acts as a “sponge” to hold the anti-icing liquid near the surface of the bridge deck or pavement and is slowly released back to the surface to act as an anti-icer preventing frost, ice, or snow to bond to the surface. A brief report describing the laboratory testing that was performed to develop this system is included in the Appendix. The current epoxy system being used is made by Unitex Chemicals Company and is marketed under the trade name. “Pro-Poxy Type III DOT”. The epoxy is applied at the rate of twelve (12) gallons per 100 square foot of surface area. The gradation for the limestone aggregate meets the following sieve analysis.

U.S.H. 8 at Wolf River, Forest County Site
(Source: Port Inland Plant, Gullivar Pit, Gullivar MI.)

<u>Sieve Size</u>	<u>% Passing</u>
1/2”	100
3/8”	100
1/4 “	100
#4	90-98
#6	62-81
#8	38-64
#10	29-56
#16	12-35
#30	4-19
#40	2-14
#50	1-9
#100	0.3-3.5
#200	0.0-1.1

I.H. 535 at Superior, Wisconsin and
U.S.H. 53 at U.S.H. 2 Interchange, Douglas County Sites
(Source: Vulcan McCook Pit, Chicago IL.)

<u>Sieve Size</u>	<u>% Passing</u>
5/16"	98-100
#4	40-60
#8	0-10

The aggregate is applied at the rate of 4-6 pounds per square feet, or three cubic yards per 1,000 square feet of surface area. The total thickness of a single lift of the overlay is approximately 3/8" inches. The finished surface has the consistency of "coarse sand paper". The overlay system is estimated to have a 10 to 15 year wear life.

The epoxy bonds the aggregate to the surface but does not seal the pours in the limestone aggregate allowing the aggregate to "soak up" an anti-icing liquid application. The residual effect from the aggregate/anti-icing liquid interaction allows for a minimum (one to five) number of liquid applications during the winter season. Cargill Salt is currently marketing the anti-icing overlay system under the name of "Safe Lane".

III. Test and Evaluation Sites

WisDOT selected a bridge in Forest County for the first installation of this anti-icing overlay system in Wisconsin. The following table lists specifics for this test and evaluation location:

Location: U.S.H. 8, Forest County, over Wolf River
6.5 miles west of Crandon, WI.
Bridge: # B-21-1 Original Construction: 1960
Deck Replacement: 1982
Deck Dimensions: 33'4"(W) x 135' (L)
(Refer to Appendix for bridge plans)
Traffic Count: 4,000 AADT two directional (2002 data)
Maintained by: Forest County Highway Department

The second Wisconsin installation of the anti-icing overlay system was made at an on grade approach ramp to the Blatnik Bridge in Douglas County, at Superior, Wisconsin. The following table lists specifics for this test and evaluation installation:

Location: I.H. 535, Douglas County northbound approach ramp to Blatnik
Bridge connecting Superior, WI. and Duluth, MN.
Original Construction:
Treated Area: 26' (Avg. Width) x 728' (L)
(Refer to Appendix for ramp plans)
Traffic Count: 10,800 AADT one direction (2002 data)
Maintained by: Minnesota D.O.T. with some assistance from Douglas
County Highway Department and City of Superior DPW

The third Wisconsin installation was made on a bridge deck on U.S.H. 53 over U.S.H. 2 approximately 12 miles south of Downtown Superior, Wisconsin. The following table lists specifics for this test and evaluation installation:

Location: U.S.H. 53, Douglas County, northbound lane over U.S.H. 2, northbound pavement lanes, and U.S. H. 2 northbound ramp to U.S.H. 53.
Bridge: # B-16-0048
Original Construction: 1981
Treated Area: Bridge Deck-26' (W) X 163'(L) + USH 53 Pavement-26' (W) X 800' (L) + USH 2 Ramp Pavement-45'(Avg. W) X 540' (L)
Traffic Count: 3,700 AADT one direction on bridge deck (2005 data)
Maintained by: Douglas County Highway Department.

IV. **Anti-Icing Overlay System Applications**

The anti-icing, overlay system was applied to the U.S.H. 8 at Wolf River bridge deck during the period from July 24, 2003 to July 29, 2003. Application included the following steps:

1. Bridge deck surface sandblasted (50⁰ F – 85⁰ F pavement temperature range);
2. Application of epoxy material (12 gals. / 100 sq. ft.);
3. Application of aggregate (3 cu. yds. / 1,000 sq. ft.);
4. Sweeping and collection of excess aggregate; and
5. Dragging of final surface to grind down high spots

The anti-icing overlay system was applied in a single lift on the entire width and length of the bridge deck surface. The overlay system was diamond grinded on June 3, 2004.

The anti-icing overlay system was applied to the Blatnik Bridge approach ramp during the period from June 20, 2005 to June 23, 2005. Existing concrete pavement preparation work was performed during the week of June 6, 2005. The system was installed in two lifts on the entire width of the ramp for a distance of 728 feet. A third lift was applied to portions of the treated area in September, 2006.

The anti-icing overlay system was applied to the U.S.H. 53 north approach pavement, bridge deck, north departure pavement, and U.S.H. 2 on ramp during the month of September, 2006. The system was installed in two lifts on the entire width of the approach pavement, bridge deck, departure pavement and ramp for a total distance of approximately 1,500 feet.

Liquid Anti-Icing Applications, 2003 - 2004 thru 2006-2007 Winter Seasons

The Forest County Highway Department's anti-icing program consists of the application of liquid $MgCl_2$ ("FreezeGard M-95" consisting of 95% $MgCl_2$ and 5% corrosion inhibitor) applied with a mobile, anti-icing applicator (Refer to the Appendix for a photo of the applicator equipment). The $MgCl_2$ product is applied at 30 gallons per lane mile, or approximately 1.9 - 2.0 gallons of liquid $MgCl_2$ on the test bridge per application, approximately one application per month.

The Forest County Highway Department is responsible for winter maintenance of ten bridges on the state highway system. Only two of these ten bridges are treated with $MgCl_2$ for frost and ice control (including the U.S.H. 8 test bridge). The other eight bridges have not had a history of frost or ice incidents due to their size or height clearance under the bridge deck.

The Minnesota Department of Transportation's anti-icing program consists of the application of liquid $MgCl_2$ (28% solution of "FreezeGard" with a rust inhibitor) applied with a mobile, anti-icing applicator. The $MgCl_2$ product is applied at 20 gallons per lane mile on an every two-week application cycle.

The Douglas County Highway Department is responsible for winter maintenance of the state highway system in Douglas County including pavements and bridge decks. The Douglas County anti-icing system consists of the application of a liquid magnesium chloride product applied with a mobile, anti-icing applicator. The $MgCl_2$ product called "FreezeGard M-95 is applied at 30 gallons per lane mile as needed in accordance with weather forecast for frost or snow.

VI. **Data Collection**

A. **2003-2004 Winter Season Data**

The following data was reported by Forest County Highway Department for the 2003-2004 winter season:

Total Snowfall:	140"
Total Storm Events:	47
Total Incidents:	15
Drifting & Blowing Snow	12
Ice	7
Frost	3
Storm Clean Up	8
Anti-Icing Applications (County Wide):	3
Salt Usage (County Wide):	$\frac{4,780 \text{ tons}}{336.2 \text{ lane miles}} = 14.2 \frac{\text{tons}}{\text{L.M.}}$

2004-2005 Winter Season Data

The following data was reported by Forest County Highway Department for the 2004-2005 winter season:

Total Snowfall:	101"	
Total Storm Events:	37	
Total Incidents:	18	
Drifting and Blowing Snow	12	
Ice	10	
Frost	0	
Storm Clean Up	14	
Anti-Icing Applications(County Wide)	4	
Salt Usage (County Wide):	$\frac{4,660 \text{ tons}}{336.2 \text{ lane miles}}$	= 13.9 $\frac{\text{tons}}{\text{L.M.}}$

2005-2006 Winter Season Data

The following data was reported by Forest County and Douglas County Highway Departments for the 2005-2006 winter season:

	U.S.H. 8, Forest County	I.H. 535, Douglas County
Total Snowfall:	104"	167"
Total Storm Events:	52	49
Total Incidents:	12	26
Drifting and Blowing Snow	14	17
Ice	4	8
Frost	0	1
Storm Clean Up	6	8
Anti-Icing Applications:(CountyWide)	3	0
Salt Usage(CountyWide):	$\frac{5,212 \text{ tons}}{312.38 \text{ L.M.}}$	$\frac{6,228 \text{ tons}}{436.65 \text{ L.M.}}$
	= 16.7 $\frac{\text{tons}}{\text{L.M.}}$	= 14.3 $\frac{\text{tons}^*}{\text{L.M.}}$

(* = no Douglas County salt applied to test site)

2006-2007 Winter Season Data

The following data was reported by Forest County and Douglas County Highway Departments for the 2006-2007 winter season:

	U.S.H. 8, Forest County	I.H. 535 and U.S.H. 53, Douglas County
Total Snowfall:	89"	162"
Total Storm Events:	30	44
Total Incidents:	17	23
Drifting and Blowing Snow	11	11
Ice	8	14
Frost	1	3
Storm Clean Up	5	6
Anti-Icing Applications: (CountyWide)	5	8
Salt Usage (CountyWide):	<u>3,584 tons</u> = 11.5 <u>tons</u>	<u>4,011 tons</u> = 9.1 <u>tons</u>
	312.38 lane miles L.M.	439.23 lane miles L.M.

B. Bridge Deck Winter Treatments and Incident Logs

Forest County Highway Department reported five anti-icing applications of liquid $MgCl_2$ (once per month); three frost incidents, and one ice incident at the U.S.H. 8 test site area during the 2003-2004 winter season. There were no occurrences of actual frost or ice on the bridge deck driving lanes reported during the winter season. Refer to the Progress Report #3 Appendix for the 2003-2004 treatment and incident log at the test site.

Forest County Highway Department reported seven anti-icing applications of liquid $MgCl_2$; one frost incident; and six freezing rain events at the U.S.H. 8 test site during the 2004-2005 winter season. There were no reports of actual frost or ice on the bridge deck driving lanes during the winter season. Refer to the Progress Report #3 Appendix for the 2004-2005 treatment and incident log at the test site.

Forest County Highway Department reported eight anti-icing applications of liquid $MgCl_2$; no frost incidents, two icing events, and 12 freezing rain events, near the U.S.H. 8 test site during the 2005-2006 winter season. There were no reports of actual frost or ice on the bridge deck driving lanes anytime during the winter season. Refer to the Progress Report #3 Appendix for the 2005-2006 treatment and incident log at the test site.

Forest County did not keep an incident log during the 2006-2007 winter season but did report a total of five anti-icing applications during the winter.

Minnesota Department of Transportation reported nine anti-icing applications of liquid $MgCl_2$ at the Superior test site during the 2005-2006 winter season. Refer to the Progress Report #3 Appendix for an example of the 2005-2006 treatment and incident log at the test site.

Minnesota Department of Transportation did not report the number of anti-icing applications of liquid $MgCl_2$ during the 2006-2007 winter season.

Douglas County Highway Department reported eight anti-icing applications of liquid M-95 during the 2006-2007 winter season at the U.S.H. 53 test site. Douglas County filed eleven field data forms for the winter season.

Standard de-icing applications of prewetted road salt are also performed at the three test sites as required during winter storm events.

C. Bridge Deck Friction Testing

The U.S.H. 8 bridge deck site was tested four times with the WisDOT ASTM skid test trailer since the application of the overlay system and twice with a Saab friction tester provided by the system installer. Friction test results were as follows:

U.S.H. 8, Forest County, Friction Test Results

Date WisDOT ASTM Friction Trailer (1)(2)

	E.D.L.	W.D.L.
9/26/03	56.8	48.0
6/03/04	53.1	47.0
10/01/04	49.5	50.6
4/18/05	52.5	53.4
8/14/06	45.4	45.1

- Notes:
1. Average values of multiple runs of the friction trailer.
 2. Friction values can vary from 0-80 with values greater than 40 considered acceptable surface friction.
 3. E.D.L. = easterly driving lane; W.D.L. = westerly driving lane

The difference in the friction values between the east bound lane and westbound lane in 2003 and 2004 may be explained by the presence of loose aggregate on the surface and the roughness of the joints of the finished surface of the overlay in the west bound lane after the application. After the friction values were obtained on June 3, 2004, the joints were diamond grinded smooth. The friction values obtained on October 1, 2004, April 18, 2005, and August 14, 2006 were more consistent between the east bound and the westbound lanes.

I.H. 535, Douglas County, Friction Test Results

Date WisDOT ASTM Friction Trailer (1)

4/20/05	47.2
7/20/05	40.4 (adjacent PCC pavement)
7/20/05	55.7 (anti-icing overlay)
11/8/06	44.2 (adjacent PCC pavement)
11/8/06 (2)	55.0 (anti-icing overlay)

- Notes:
1. Average values of multiple runs of the friction trailer.
 2. Friction values obtained after application of second lift of overlay material in September, 2006.

**U.S.H. 53 at U.S.H. 2 Bridge and Ramp, Douglas County
Friction Test Results**

<u>Date</u>	<u>WisDOT ASTM Friction Trailer (1)</u>
11/8/06	58.5 (U.S.H 53 bridge driving lane)
11/08/06	60.8 (U.S.H. 53 bridge passing lane)
11/08/06	55.3 (U.S.H. 2 northbound on ramp to U.S.H. 53)

- Notes:
1. Average values of multiple runs of the friction trailer.

D. Roughness Measurement (IRI) Testing

The U.S.H. 8 bridge deck test site was tested with the Wisconsin D.O.T. "Road Profiler" in June, 2005 and May, 2006. The roughness measurement (IRI) results were as follows:

	June 2005	May 2006
Eastbound lane	5.92 m/km	4.48 m/km
Westbound lane	5.32 m/km	5.28 m/km

The Blatnik Bridge site was tested with the Wisconsin D.O.T. "Road Profiler" before and after the anti-icing overlay installation in 2005 and in 2006. Roughness measurement (IRI) test results were as follows:

<u>Date</u>	<u>"Road Profiler" (IRI) (m/km) Measurement</u>
6/??/05	2.61 (5)
7/??/05	3.06 (adjacent PCC pavement)
7/??/05	4.32 (anti-icing overlay)
10/29/06	4.05

- Notes:
5. Average of two runs of the "Road Profiler".
 6. IRI Scale ranges from 0.00 (new pavement) to 12.00 (severely damaged pavement).

The U.S.H. 53 site was tested with the Wisconsin D.O.T. "Road Profiler after the anti-icing overlay installation in 2006. The roughness measurement (IRI) test results were as follows:

<u>Date</u>	<u>"Road Profiler (IRI) (m/km) Measurement</u>
10/29/06	1.56 (driving lane, left wheel path)
10/29/06	1.70 (driving lane, right wheel path)
10/29/06	2.21 (passing lane, left wheel path)
10/29/06	2.00 (passing lane, right wheel path)

E. Reported Crashes at U.S.H. 8 Test Location

Crash Reports for the bridge deck and approaches recorded during the winter seasons for the period from November, 1994 through April, 2003 and November, 2003 through April, 2007 were reviewed. Four crash reports were filed between November, 1994 and April, 2003 where the crash occurred on the bridge deck or bridge approaches. No crashes were reported for the period from November, 2003 to April, 2007. The county patrol superintendent estimated that there had been two to three crashes per winter season at the bridge site when a crash report was not filed due to minor damage and/or any injuries or deaths. The county highway department had been performing guardrail repairs at the site (at a cost of \$1,500-\$2,000 per event) on an annual schedule from 1994 through 2003. No guardrail repairs were required after any of the three winter seasons.

F. Reported Crashes at I.H. 535 Test Location

A review of crash reports for the northbound approach ramp indicated that approximately ten snow or ice related crashes had been reported during the 2000-2001 thru 2003-2004 winter seasons. No crashes were reported for the 2005-2006 or 2006-2007 winter seasons.

G. Reported Crashes at U.S.H. 53 Test Location

A review of crash reports and incidents reports from the Douglas County Sheriff's Department for the U.S.H. 53 bridge deck and U.S.H. 2 northbound on ramp indicated that there were no snow or ice related crashes on the bridge deck or ramp during the 2006-2007 winter season. There was one slide off crash reported on January 12, 2007 at 3:30 a.m. in the vicinity of the bridge deck but no crash reported was filed and the details of the incident were not available.

Douglas County reported that there was slide off crashes at this site "almost during every snow storm" previous to the 2006 overlay installation.

VII. **Observations During the 2003-2004 through 2006-2007 Winter Seasons**

The Forest County Highway Department patrol supervisor reported the following observations after the 2003-2004 winter season at the U.S.H. 8 test site:

1. The anti-icing overlay surface required only one liquid $MgCl_2$ application per month unless a rain or freezing rain event flushed the liquid from the surface. Then a reapplication would have to be made.
2. Frost or black ice did not accumulate on the bridge deck surface when it was reported at other locations in the county.
3. No call-ins from local law enforcement agencies concerning the condition of the bridge deck were recorded.
4. Snow that accumulated on the bridge deck was easy to remove by a plowing operation.
5. Snowplow blade wear for the plow mounted on the truck that maintains the patrol section including the test bridge was not any more severe than it was prior to the installation of the anti-icing overlay.

The Forest County Highway Department patrol supervisor reported the following observations after the 2004-2005 winter season at the U.S.H. 8 test site:

1. Plowing has not removed any aggregate from the overlay surface.
2. The winter patrol truck that maintains the patrol section that includes the test bridge has not used any more snowplow blades than patrol trucks on other patrol sections.
3. Snow does not pack down on the overlay surface and is easy to remove by a plowing operation.

The Forest County Highway Department patrol supervisor reported the following observations after the 2005-2006 winter season at the U.S.H. 8 test site:

1. No icing of the bridge deck surface during or after multiple freezing rain events.
2. Traction on the bridge deck surface was good during snow events.
3. No call-in telephone calls from law enforcement agencies reporting an icy or slippery bridge deck surface.
4. No reported crashes occurred on or immediately adjacent to the bridge deck or approaches.

5. No noticeable damage to the anti-icing overlay surface from snow plow blades and no cracking or peeling off of the anti-icing overlay material.

No new comments for this site were reported after the 2006-2007 winter season.

The Minnesota Department of Transportation, Duluth office representatives reported the following observations after the 2005-2006 winter season at the I.H. 535 test site:

1. The anti-icing overlay surface “holds the liquid $MgCl_2$ applications” longer than the adjacent non-overlaid pavement.
2. During snow events, the treated area had better traction when snow covered than the adjacent non-overlaid pavement.
3. The anti-icing overlay area does not become snow covered as soon as the adjacent non-overlaid pavement.
4. The operators were able to lower the salt application rate and the number of salt applications on the anti-icing overlay surface compared to the adjacent non-overlaid pavement.
5. After a rain or freezing rain event, the liquid anti-icing application was diluted and a reapplication was needed.
6. There was less loss of vehicle control in the anti-icing overlay area.
7. The overlay material appeared to hold up well during the winter season and did not ride rougher than the adjacent pavement.

No new comments for this site were reported after the 2006-2007 winter season.

The Douglas County patrol supervisor reported the following observations at the U.S.H. 53 and U.S.H. 2 test sites after the 2006-2007 winter season:

1. Surface performed well during a freezing rain event in December 2006.
2. The anti-icing overlay areas stayed wet longer and did not become snow covered as fast as the adjacent bridges and pavement areas during a snow event.
3. Heavy, wet snow accumulated on the surface but the snow was removed easily, and clean up of the surface went faster than on adjacent sections.
4. No frost accumulation was observed on the bridge deck.
5. No surface refreeze was observed after the application of $MgCl_2$.

6. There was no beam guard damage from vehicle slide-offs adjacent to the bridge deck.

VIII. **Conclusions**

The following conclusions about the anti-icing overlay system are based on observations made during the installation of the anti-icing overlay and following up to four winter seasons of in service operation:

1. Installation techniques in 2003 at the U.S.H. 8 test site were very labor intensive. The installation process has been refined and was more efficient at the Blatnik Bridge test site in 2005 and the U.S.H. 53 test site in 2006.
2. Concrete pavement preparation work at the Blatnik Bridge on grade test site was more intensive than at the U.S.H. 8 bridge test site.
3. Friction values obtained on the anti-icing overlay were equivalent to numbers obtained on dry pavements.
4. One $MgCl_2$ application per month at 30 gallons per lane mile, or 20 gallons per lane mile every two weeks were adequate for preventing frost or ice on the overlay unless a rain or freezing rain event diluted the $MgCl_2$ application on the bridge deck or the pavement surface. Then a reapplication was necessary at both sites.
5. The anti-icing overlay appears to be preventing vehicle crashes on the bridge decks, bridge approaches, and ramp pavements.

IX. **Recommendations**

The following recommendations are made based on experience with the anti-icing overlay during the 2003-2004 through 2006-2007 winter seasons:

1. The installation techniques used for the anti-icing overlay system need to be made more mechanical in order to make the installation more cost effective.
2. The Forest County Highway Department, the Minnesota Department of Transportation, the Douglas County Highway Department, and the Bureau of Highway Operation need to continue to monitor the performance of the anti-icing overlay systems in order to determine their long-range performance by continuing to perform friction measurements, ride quality measurements, and visual observations.

Appendix

(REFER TO PROGRESS REPORT #3 FOR ALL APPENDIX ITEMS)

1. Unitex Pro-Poxy, Type III, DOT Data Sheet-U.S.H. 8 Test Site-2003
2. Aggregate Gradation – U.S.H. 8 Test Site - 2003
3. Unitex Smart Bond –U.S.H. 535 Test Site-2005
4. Technical Specifications and Installation Specifications – I.H. 535 Test Site - 2005
5. Laboratory Test Results Report – April, 2002
6. Project Location Maps - Forest and Douglas County
7. Bridge (B-21-1) Plan & Blatnik Bridge Approach Plan Sheet
10. Installation Photos, U.S.H. 8 Test Site, July 2003
11. Anti-Icing Applicator and Friction Testing Equipment Photos
12. Installation Photos, I.H. 535 Test Site, June 2005
13. Treatments and Incident Logs, 2003-2004, 2004-2005, and 2005-2006 Winter Seasons-U.S.H. 8 and I.H. 535 Test Sites