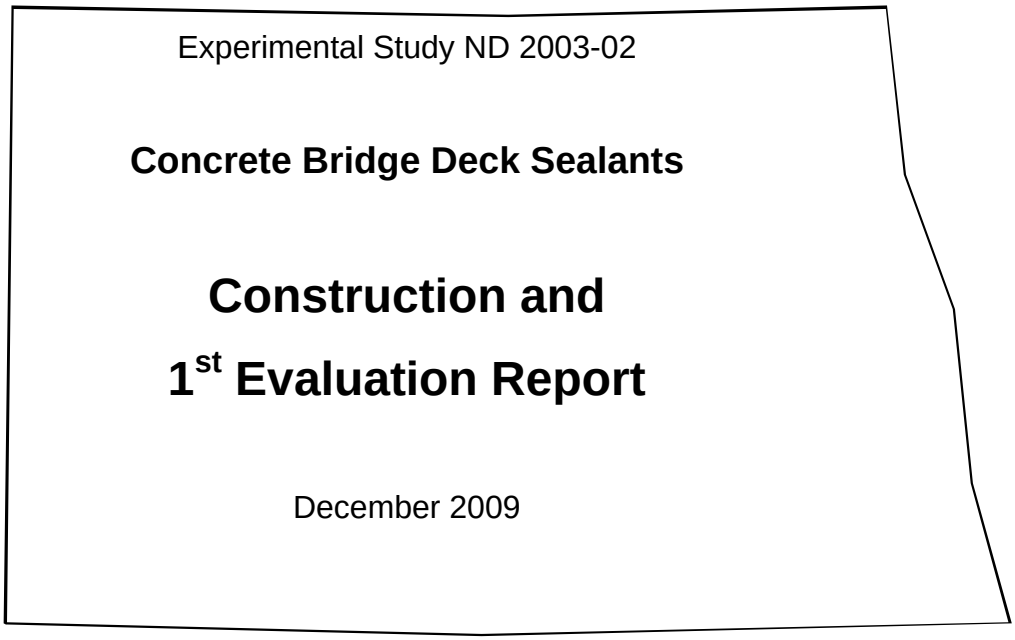
NORTH DAKOTA

DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 2003-02

Concrete Bridge Deck Sealants

Construction and

1st Evaluation Report

December 2009

Prepared by

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO. (1)

STATE	Y EAR		NUMBER	SURF
ND	2003	-	02	

CONSTRUCTION PROJ NO (8): IM-2-094(070)275

LOCATION (28): Barnes County

EVALUATION FUNDING (48)

1 X HP&R
2 CONSTRUCTION
3 DEMONSTRATION
4 IMPLEMENTATION

NEEP NO. (49):

PROPRIETARY FEATURE? (51): Yes / X No

SHORT TITLE

TITLE (52): Concrete Bridge Deck Sealants

THIS FORM

DATE (140): MO. 03 -- YR. 2009

REPORTING: 1 X INITIAL 2 X ANNUAL 3 FINAL

KEY WORDS

KEY WORD 1 (145): Concrete

KEY WORD 2 (167): Sealants

KEY WORD 3 (189): BridgeDecks

KEY WORD 4 (211):

UNIQUE WORD (233):

PROPRIETARY FEATURE NAME (255):

CHRONOLOGY

Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
277 10-2003	281 07-2004	285 07-2014	289	293

QUANTITY AND COST

QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS)	UNITS	UNIT COST (*Dollars, Cents*)
297	1 LIN. FT, 2 SY, 3 SY-IN, 4 CY, 5 TON, 6 LBS, 7 EACH, 8 LUMP SUM (305)	306

AVAILABLE EVALUATION REPORTS

CONSTRUCTION	PERFORMANCE	FINAL
315	X	

EVALUATION

CONSTRUCTION PROBLEMS (318)

1 X NONE
2 SLIGHT
3 MODERATE
4 SIGNIFICANT
5 SEVERE

PERFORMANCE (319)

1 EXCELLENT
2 GOOD
3 SATISFACTORY
4 MARGINAL
5 UNSATISFACTORY

APPLICATION (320)

1 ADOPTED AS PRIMARY STD.
2 PERMITTED ALTERNATIVE
3 ADOPTED CONDITIONALLY
4 PENDING
5 REJECTED
6 NOT CONSTRUCTED

(Explain in remarks if 3, 4, 5, or 6 is checked)

REMARKS

321 The Tamms and Degusa product have areas where excess material has been applied to the deck surfaces. This is most noticeable in the deeper tined concrete. Cracks are visibly sealed with these sealers. The Radcon product is unnoticeable as to the amount of sealer applied when dry. The depth of tining remains unchanged when Radcon is applied. It is unclear if the cracks in the Radcon section are sealed as the sealer is intended to penetrate the surface and form a gel in the cracks. The chloride sampling and chain dragging results are summarized in Tables 6 and 7. From the results of these tests it is difficult to draw conclusions to whether or not the products are meeting the manufacturer's performance characteristics.

Form FHWA 1461

Experimental Study ND 2003-02

Concrete Bridge Deck Sealants

Construction and 1st Evaluation Report

Project AC-IM-2-094(070)275

December 2009

Written by

Bryon Fuchs

and

Andy Mastel

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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Concrete Bridge Deck Sealants
ND 2003-02

Purpose and Need

The NDDOT uses concrete as their primary construction material in designing and building bridges. Concrete is primarily used due to the availability of concrete and it also offers an economical benefit over other materials available to the NDDOT. The concrete we are primarily concerned with is located in the bridge deck (part of the super structure), which is used to carry traffic across the structure.

Concrete has some undesirable properties; it is subject to structural distresses such as cracking, it is porous which allows the intrusion of water and deicing chemicals, and its strength is poor under tensile loading conditions. In order to improve the tensile characteristics of concrete, steel reinforcement is added. Due to the porosity of the concrete and its inherent cracking characteristics, pathways in the concrete allow water and chloride ions to penetrate the concrete.

When moisture and the chloride ions penetrate deep enough, the reinforcing steel starts to corrode. This corrosion causes extreme pressure in the concrete due to the volume change in the steel. This volume change starts to slowly break the concrete apart. With the intrusion of water into the concrete, small voids are filled with water and become susceptible to freeze thaw cycles causing internal expansion within the concrete resulting in deterioration.

The separation of the concrete within itself or at the bond between the concrete and reinforcing steel is known as delamination. Delaminated concrete can break free from the surrounding concrete causing major damage to vehicles traveling across the structure, ride quality becomes very poor, and can also cause further deterioration to the bridge deck due to exposure of the surrounding elements.

When a bridge deck is 20% delaminated, a bridge deck overlay is usually the rehabilitation option chosen, provided the structure is not deficient or in need of replacement. However, for the bridge decks that have delamination of less than 20%, the NDDOT does not currently have another rehabilitation or maintenance option

available for use.

Objective

For bridge decks with very little delamination, another alternative needs to be available to protect the concrete so the bridge can remain in service for a longer time before the public is inconvenienced by rehabilitation of the bridge deck. One method is to apply a concrete surface and crack sealer to the existing concrete bridge deck. If the delamination is from corroding reinforcing steel, the sealer may create a barrier that will stop the intrusion of water and deicing chemicals; thereby slowing the further corrosion of the steel. Further deterioration caused by the expansion of freezing water in small voids may be stopped if the intrusion of water can be halted.

This study proposes to compare the performance of several different products used to seal the concrete surface and cracks.

Project History

NDDOT project number AC-IM-2-094(070)275 was selected to incorporate this applied research. The project is located on Interstate 94 between the Eckelson Interchange and the Oakes Interchange. The NDDOT Bridge Division's memo is attached in Appendix A stating the condition and background of each bridge deck. Four concrete bridge decks located within the project limits were chosen. Please refer to Figure 1 on the next page. The years constructed and the years overlaid are below.

Bridge No.	Crossing	Size	Built	Overlaid
94-276.385	Eckelson Int.	210' x 24' Bridge	1957	1986
94-279.636	West Sanborn Sep.	210' x 24' Bridge	1958	
94-281.640	Sanborn Int.	210' x 24' Bridge	1958	1984
94-288.636	Oakes Int.	220' x 30' Bridge	1958	1986

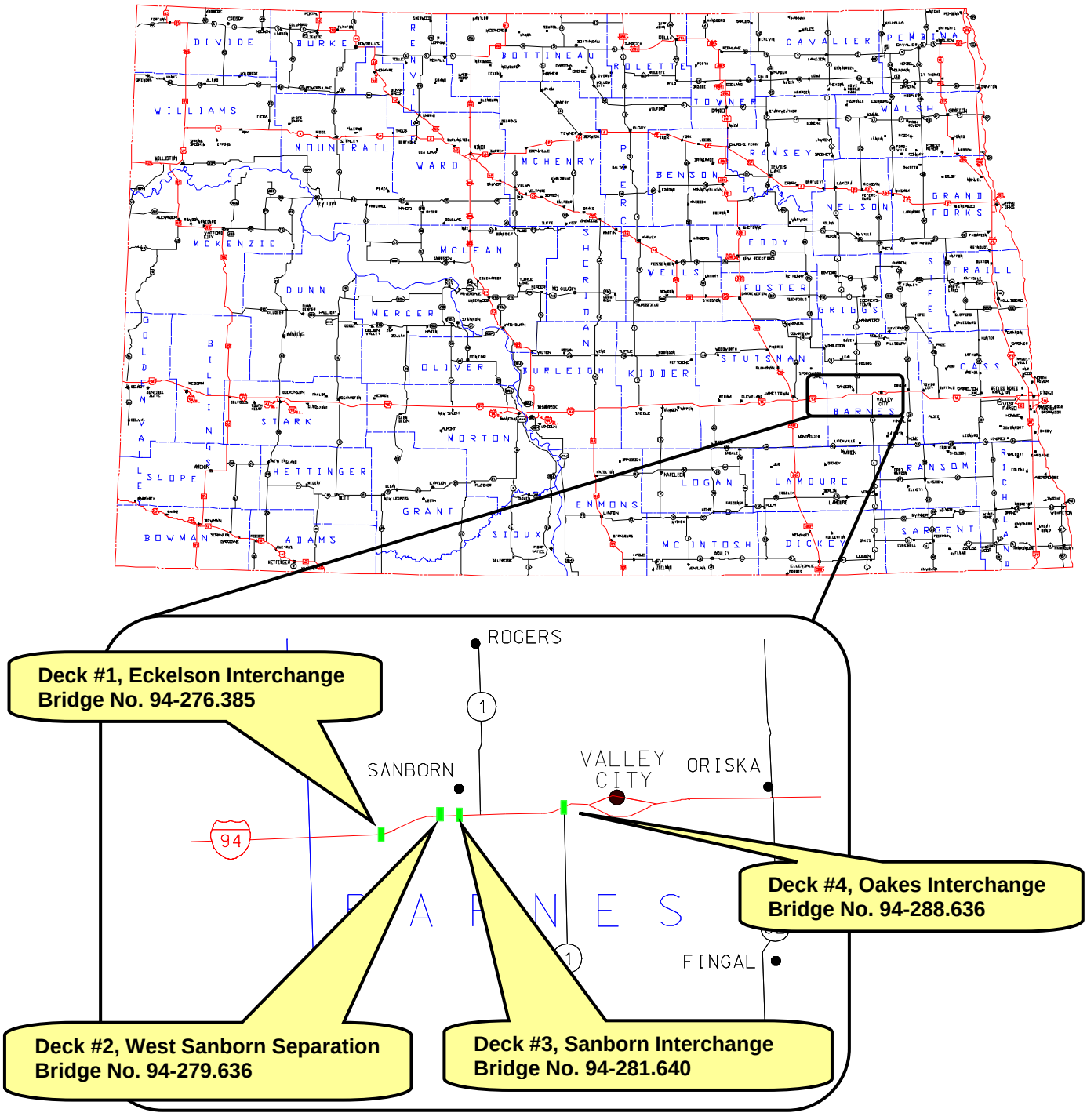


Figure 1 - Project location.

Traffic

Provided in the following table is the 2002 two-way traffic at each location except one. Traffic is unavailable for the West Sanborn Separation. The West Sanborn Separation carries local traffic and carries the least traffic out of the four bridges.

Bridge Deck	Cars	Trucks	ESALs	
			Flexible	Rigid
Eckelson	320	30	20	35
Sanborn	370	30	25	40
Oakes	740	150	110	175

Table 1: Traffic

Design

A literature search was performed and several products were chosen. The criteria used to select a product are as follows:

- Ability to seal hairline cracks and cracks up to 2 mm to 3 mm cracks.
- Ability to seal the existing concrete to reduce water and chloride ion penetration.
- Ability to maintain existing skid resistance with minimal or no additional aggregate needing to be added.
- Ease of application.
- And, short cure times so two-way traffic can be restored at the end of the day.

The three products selected are: Radcon Formula #7, Degusa Degadeck Crack Sealer, and Tamms Dural 335. Each product will be applied according to the manufacturer's recommendations.

The total deck surface area for all decks combined is 2,414 SY. Each product will be applied to approximately 25% of the total surface area of the decks with 25% of the total surface area left for control sections as shown in figure 2. Estimated costs are provided in table 2.

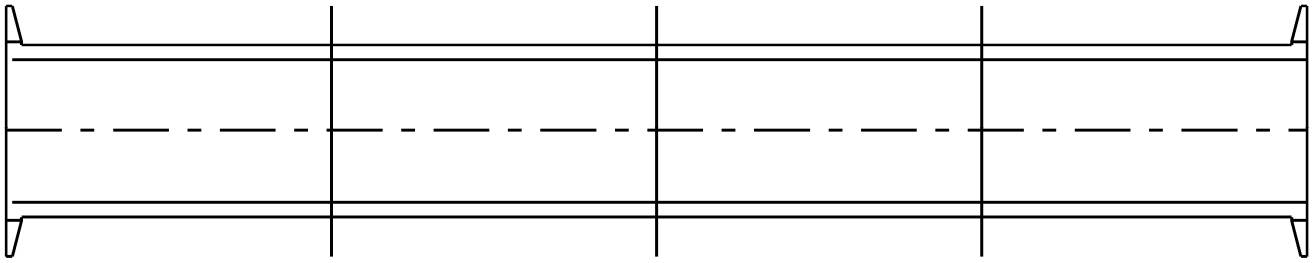


Figure 2: 25% was allowed for each sealer with one portion being a control section

Bridge Number	Crossing	Square Yards	Overlay Cost*	Sealer Cost
94-276.385	Eckelson interchange	560	$50,000	$3,640
94-279.636	West Sanborn separation	560	$50,000	$3,640
94-281.640	Sanborn interchange	560	$50,000	$3,640
94-288.636	Oakes interchange	734	$66,000	$4,771

Table 2: *Overlay cost provided by Bridge Division.

Construction

The prime contractor for project AC-IM-2-094(070)275 was the Penhall Company from Rogers, MN. The application of the concrete sealers was subcontracted to Industrial Builders, Inc. (IBI) from Fargo, ND. The project engineer for the North Dakota Department of Transportation (NDDOT) was Kathy Beach who works in the Valley City District. Gary Schlagel, NDDOT-Valley City District, was the inspector for this project. Bryon Fuchs, Kyle Evert, Steven Henrichs, and Mike Marquart from the Materials & Research Division were on-site for the initial prep work on a bridge deck and the first application of each concrete sealer in July of 2004.

A Radcon representative was on-site to assist the contractor with the proper concrete surface preparation prior to application and also assist in the proper mixing and application of the sealers. The TAMMS and Degusa representative were not available for the actual application of the sealers; however, they did instruct the contractor on the tools to use for mixing and applying the product.

Existing Bridge Deck Condition

Each bridge deck contains various size cracks ranging from hairline to 3 mm wide cracks at the surface. Prior to application of the concrete sealers, twelve chloride samples were taken per bridge deck and each bridge was chain dragged to estimate concrete delamination.

Concrete Sealer Cost

Provided in the following table are the bid prices for the sealers used.

Sealer	Unit Cost ($/SY)	Total Square Yards	Total Cost
TAMMS	24.00	603	$14,472
DEGUSA	26.00	603	$15,678
RADCON	11.00	603	$6,633

Table 3: Estimated Sealer Cost

The cost to apply the sealers was more than originally estimated. The cost difference is a result of the contractor being unfamiliar with the products and the application of the product on only 1/8 of the bridge deck at a time. Normal application of the product would be 1/2 of the bridge deck at a time.

Application of Concrete Sealers

Prior to application of the sealers, the bridge decks need to be prepped. The deck prep varies depending on the sealer used. Two bridge decks (1/2 of each deck) were prepped at a time. Radcon Formula #7 requires the deck to be free of dirt or aggregate; however, the contractor sandblasted the deck prior to applying this sealer. Tamms Dural 335 requires the deck to be sandblasted. Degusa Degadeck Crack Sealer requires the deck to be shot blasted. The photos below illustrate the deck prepping for these sealers.

Photo 1 - Sandblasting the bridge deck.

Photo 2 - Difference between sandblasted and non-sandblasted portion of the deck.

Photo 3 - Shotblasting the bridge deck.

Photo 4 - Size of shot used in shotblasting.

Photo 5 - Difference between shotblasted on the left and non-shotblasted portion of the bridge deck.

Once the bridge decks were prepped, the contractor applied the sealers to each deck. Provided in the Construction Summary are layouts of the bridge decks and the location of each sealer used.

Radcon Formula #7

Radcon Formula #7 came premixed and ready to use. This sealer was applied using a pressure backpack type sprayer. The application of this sealer was easy and no noticeable odor was observed. The sealer was applied until the surface was visibly wet for complete coverage. Cracks in the bridge deck were flooded with the sealer to ensure crack penetration. Radcon was applied at an average rate of 310 ft^2 per gallon. The manufacturer recommends an application rate of 150-170 ft^2 per gallon.

The sealer was allowed to dry until it was tack free which took approximately 30 minutes. The time to dry will vary depending on temperature, wind speed, and humidity. Once it was dry, the deck was sprayed with water so the sealer could penetrate the surface. At this time, the bridge would be able to be opened up to traffic according to the manufacturer. Water was applied two more times at 24-hour intervals for further penetration.

Provided below are photos of the application of Radcon Formula #7.

Photo 6 - Backpack sprayer and application of Radcon Formula #7.

Photo 7 - Radcon Formula #7 applied to the bridge deck.

Photo 8 - Overview of Radcon Formula #7 section of the deck after application.

Degusa Degadeck Crack Sealer

Degusa Degadeck Crack Sealer is a two part methacrylate reactive resin that needs to be mixed on the jobsite. The resin needs to be mixed with a hardener at the jobsite. Once the hardener was added the resin and mixed, the sealer was then applied using brooms. Brooms were used so excess sealer could be removed from the tining in the concrete and not waste sealer. The application of this sealer was easy; however there was a very harsh odor that was observed. During the application of this sealer, one of the contractor's labor force noticed that the soles of their shoes (tennis) were dissolving. The sealer was applied until the surface was completely covered. Before the sealer started to harden, sand was applied to help maintain skid resistance. Cracks in the bridge deck were flooded with the sealer to ensure crack penetration.

Degusa Degadeck Crack Sealer was applied at an average rate of 88.2 ft^2 per gallon. The manufacturer recommends an application rate of 100 ft^2 per gallon.

Provided on the next page are photos of the application of Degusa Degadeck Crack Sealer.

Photo 9 - Hardener that is added to the resin of Degusa Degadeck Crack Sealer.

Photo 10 - Mixing the resin and hardener of the Degusa Degadeck Crack Sealer.

Photo 11 - Applying Degusa Degadeck Crack Sealer with a broom.

Photo 12 - Broadcasting sand to help maintain skid resistance to the Degusa Degadeck Crack Sealer section.

Photo 13 - Overview of a Degusa Degadeck Crack Sealer section after sand was applied.

Photo 14 - Chemical reaction between the Radcon Formula #7 and Degusa Degadeck Crack Sealer. Radcon was applied first and did not allow the Degusa Degadeck Crack Sealer to penetrate the concrete for adherence.

Tamms Dural 335

Tamms Dural 335 is a two part epoxy resin that needs to be mixed on the jobsite. Once the two components were mixed, the sealer was then applied using squeegees. Squeegees were used to allow the sealer to fill up the cracks. Some cracks in the bridge deck were flooded with the sealer to ensure crack penetration. The application of this sealer was easy with no odor observed. The sealer was applied until the surface was completely covered. Before the sealer started to harden, sand was applied to help maintain skid resistance.

Tamms Dural 335 was applied at an average rate of 112.5 ft^2 per gallon. The manufacturer recommends an application rate of 100-200 ft^2 per gallon.

Provided below are photos showing the application of Tamms Dural 335.

Photo 15 - Hardener that is added to the Tamms Dural 335 resin.

Photo 16 - Resin or base component of the Tamms Dural 335 sealer.

Photo 17 - Mixing the resin and hardener of the Tamms Durall 335 Sealer.

Photo 18 - Applying Tamms Dural 335 Sealer with a squeegee.

Photo 19 - Applied sand to the Tamms Dural 335 sealer.

Photo 20 - Crack sealed with Tamms Dural 335.

Post Construction

The bridge decks were visited on December 8, 2004 after construction of the project had been completed for almost two months and again on April 26, 2005.

Radcon Formula #7

The bridge decks appearance in the location where Radcon Formula #7 was applied, appears as if nothing has been applied to the concrete. This is to be expected as this material is intended to penetrate the surface. The area was prepped by sandblasting and this is still evident when comparing the control section to this section.

The thickness or the amount of material applied is not evident. All of the original surface characteristics still remain after the application of the sealant.

Cracks that are located within the Radcon sections appear as they did prior to application of the sealer. This is not an indication that the cracks did not get sealed. Radcon is intended to penetrate the concrete and form a “gel” to seal up pores and cracks. Whether or not Radcon has sealed the cracks is unknown at this time but will be determined based on future chloride analysis of the concrete near the cracks. Photos 21 and 22 show conditions taken after one winter.

Photo 21 - Overview of a Radcon Formula #7 section.

Photo 22 - Crack in a Radcon section. Unable to visibly see if the crack is sealed.

Degusa Degadeck Crack Sealer

The bridge decks appearance in the location where Degusa Degadeck Crack Sealer was applied appears as a yellowish tint or film on the concrete. The thickness or the amount of material applied is very evident and the thicker the applied material, the more yellow the concrete.

Larger cracks that are located within the Degusa sections appear to be sealed by evidence of the sealing agent in the cracks. Smaller or hairline cracks appear to be sealed as well.

During construction, the Radcon representative applying the sealer went past the designated section for their product and is visibly noticeable. This happened in two locations. In these areas, both products (Degusa and Radcon) were applied the same day. It appears that the Radcon did not allow the Degusa product to adhere to the surface. The Radcon sealer requires a total of three applications of water to help penetrate the concrete. This was not done prior to the application of the Degusa product. It is unclear if the Degusa product would have adhered to the concrete if the Radcon sealer had had the three applications of water prior to application of the Degusa product. Provided below are photos 23. 24, and 25 taken after one winter.

Photo 23 - Overview of a Degusa Degadeck Crack Sealer section.

Photo 24 - Popouts filled with Degusa sealer.

Photo 25 - Excess material applied in a Degusa section. Applied sand is visibly noticeable as well.

Tamms Dural 335

The bridge decks appearance in the location where Tamms Dural 335 was applied appears to have no visible color. The thickness or the amount of material applied does not seem to affect the clarity of the material.

Larger cracks that are located within the Tamms sections appear to be sealed by evidence of the sealing agent in the cracks. Smaller or hairline cracks appear to be sealed as well.

The application of this product was conducted using a squeegee. Using a squeegee to apply this product on a tined surface leaves too much material in the tining. If this product is to be used in the future, a broom should be used to reduce the amount of material needed. A broom will still allow enough material to fill the larger cracks.

Photos 26, 27, and 28 show the condition of this section after one winter.

Photo 26 - Overview of a Tamms Dural 335 section.

Photo 27 - Material in popout. Note the Tamms material is clearer than the Degusa product.

Photo 28 - Crack filled with Tamms Dural 335.

Construction Summary

The layout of where the sealers were installed is shown in figures 3 through 6.

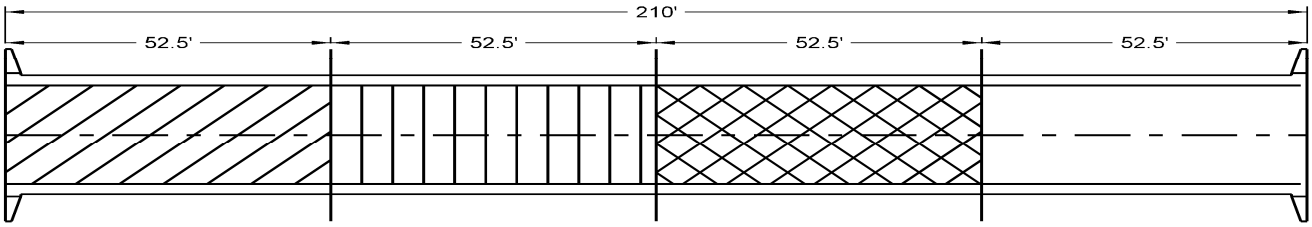


Figure 3: Eckelson Interchange Sealer Layout

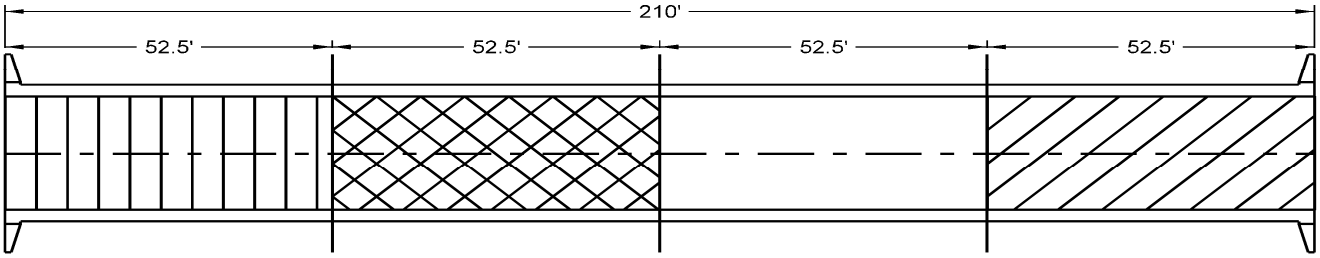
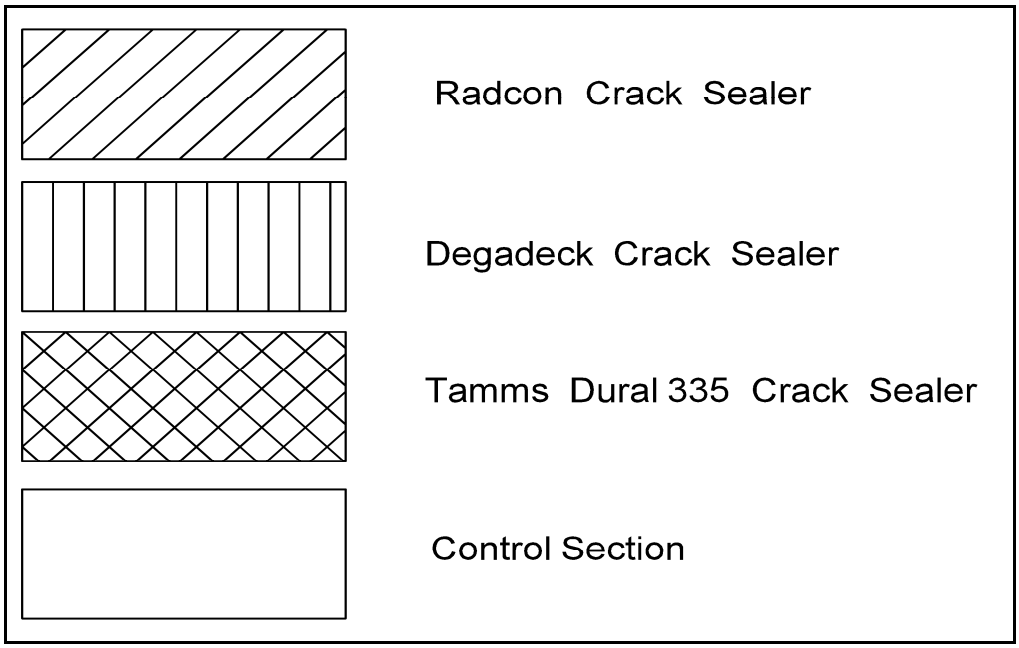


Figure 4: West Sanborn Sealer Layout



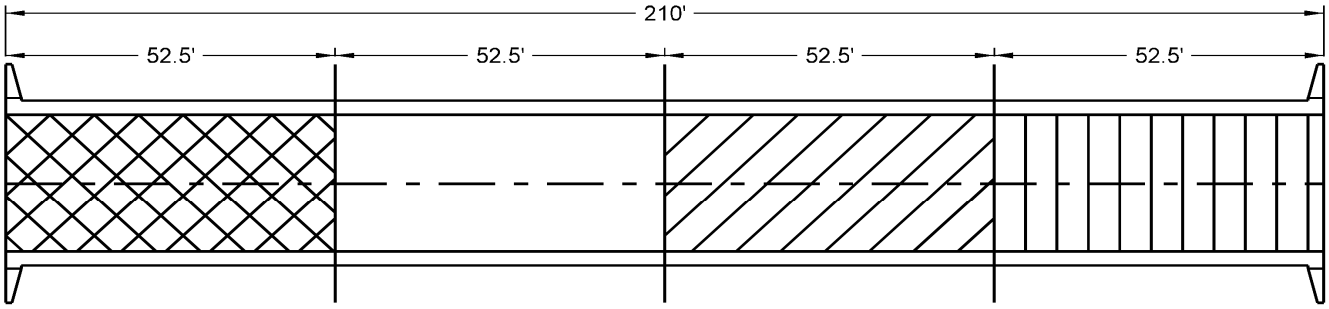


Figure 5: Sanborn Interchange Sealer Layout

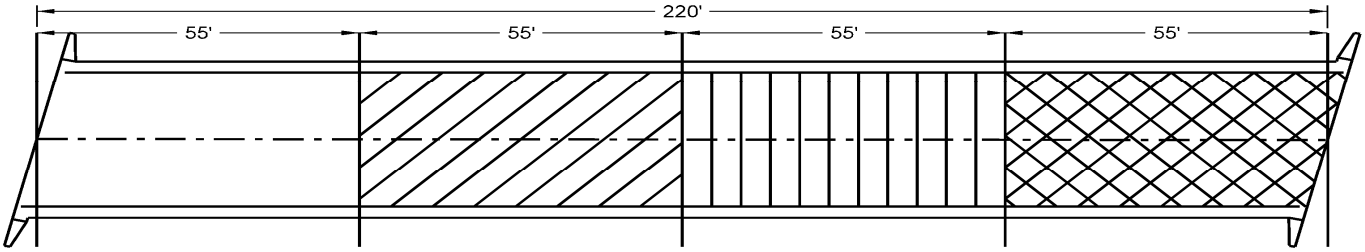
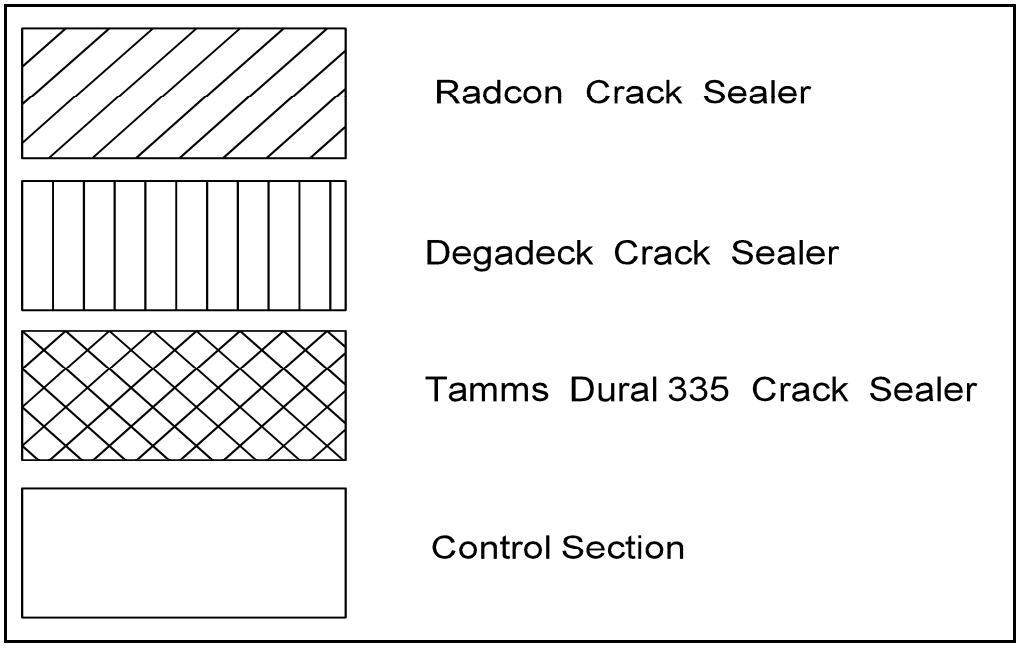


Figure 6: Oakes Interchange Sealer Layout



The existing bridge decks contain cracks ranging from hairline to 3 mm cracks at the surface. Chain drag results on each deck shows different severity of delamination. A summary of the delamination results can be found in table 6 on the following page**.**

Provided in table 4 are the costs for the sealers used which includes; preparing the bridge decks, the sealers, and application of the sealer. These costs are higher than originally estimated. The cost to apply these sealers was higher due to the contractor's unfamiliarity with the products and each sealer could only be applied to 1/8 of the deck at a time. Normal application would be to apply sealer to 1/2 of the deck at a time.

Sealer	Unit Cost ($/SY)	Total Square Yards	Total Cost
TAMMS	24.00	603	$14,472
DEGUSA	26.00	603	$15,678
RADCON	11.00	603	$6,633

Table 4: Actual Cost

The Tamms product requires the surface to be sandblasted. The Degusa product requires the surface to be shot blasted. The Radcon product requires the surface to be clean, free of debris, and moisture. However, the contractor sandblasted the portion of the deck that Radcon was applied to.

The sealers were easy to apply. The Tamms and Degusa product required mixing prior to application. The Tamms and Degusa products were poured on to the deck and then spread over the deck with a squeegee and broom respectively. The Tamms product had virtually no odor, while the Degusa product had a very harsh odor. The Radcon product required no mixing. Radcon was applied by a backpack type sprayer with no noticeable odor. Provided in table 5 are the application rates of the material.

Sealer	Application Rate (ft^2/gal)	Manufacturer Recommended Application Rates (ft^2/gal)
Tamms	112.5	100 to 200
Degusa	88.2	100
Radcon	310.0	150 to 170

Table 5: Application Rates

The Tamms and Degusa product have areas where excess material has been applied to the deck surfaces. This is most noticeable in the deeper tined concrete. Cracks are visibly sealed with these sealers. The Radcon product is unnoticeable as to the amount of sealer applied when dry. The depth of tining remains unchanged when Radcon is applied. It is unclear if the cracks in the Radcon section are sealed as the sealer is intended to penetrate the surface and form a gel in the cracks.

1st Evaluation

The first evaluation was conducted on May 14, 2008. Materials and Research personnel, Andy Mastel and Steven Henrichs, took chloride samples while the Valley City district conducted chain dragging of the four bridge decks. The delaminated square footage for each bridge deck section is shown below in table 6.

Chain Dragging Results (ft^2 delaminated for each area)					
		Sealers			
		Radcon	**Tamms**	**Degusa**	**Control**
Eckelson Interchange	2004	27.9	0.8	13.7	9.2
	2008	26.4	6.9	24.6	0
West Sanborn Seperation	2004	71.1	183.8	36.9	254.5
	2008	29.5	83.7	16.1	193.7
Sanborn Interchange	2004	68.2	107	18	31.6
	2008	29.2	52.3	20.4	6.8
Oakes Interchange	2004	98.1	123.3	38.9	35.5
	2008	129.1	121.11	172.7	8.1

Table 6: Estimated area of delamination

The chloride test results for 2004 and 2008 are shown below in Table 7.

units(lb/cu.in.)		Radcon Sealer		Degusa Sealer		Tamms Sealer		Control	
Location	Test	2004	2008	2004	2008	2004	2008	2004	2008
Eckelson Interchange	**1**	5.11	3.80	4.70	3.48	2.23	1.06	4.38	4.68
	2	7.40	4.97	4.56	3.92	3.05	1.37	9.28	3.21
	3	2.00	1.68	3.76	4.66	4.89	2.54	4.42	2.62
	Avg.	4.84	3.48	4.34	4.02	3.39	1.66	6.03	3.50
West Sanborn Seperation	**1**	0.59	0.82	0.59	0.98	2.51	0.43	0.78	0.43
	2	0.63	0.86	1.10	0.98	0.74	0.70	1.21	0.74
	3	0.84	1.14	0.74	0.86	0.70	0.39	1.10	0.82
	Avg.	0.69	0.94	0.81	0.94	1.32	0.51	1.03	0.66
Sanborn Interchange	**1**	1.02	0.94	2.19	2.27	3.09	2.04	2.58	2.74
	2	1.02	1.06	1.61	0.90	2.11	1.25	0.74	1.37
	3	6.77	8.10	2.76	3.29	5.32	4.54	3.25	3.48
	Avg.	2.94	3.37	2.19	2.15	3.51	2.61	2.19	2.53
Oakes Interchange	**1**	4.66	3.60	2.35	5.79	2.19	1.96	3.76	6.15
	2	4.78	2.19	9.55	6.54	11.43	7.13	5.91	3.25
	3	5.89	5.60	10.57	6.26	13.53	10.94	11.67	4.93
	Avg.	5.11	3.80	7.49	6.20	9.05	6.68	7.11	4.78

* Refer to Appendix C for chloride test locations. The 2008 locations were 3 inches east of the 2004 locations.

Table 7: Chloride Test Results

The chloride test locations and delamination locations are shown in Appendix C.

Visually the Radcon Formula #7 appeared to look the same as the control section on each bridge deck. It is unclear if the cracks in the Radcon section are sealed as the sealer is intended to penetrate the surface and form a gel in the cracks.

The Degussa Degadeck had a white appearance on the surface and had a yellowish tint in the tining. The Tamms Dural surface also looked the same as the control sections, however, sealer was apparent in the tining of the Tamms Dural and the Degussa Degadeck on all of the bridge decks.

Materials and Research conducted a visual evaluation during the spring of 2009 after a moisture event had occurred the night before. The advantage being the cracks in the decks would be easier to see.

Eckelson Interchange

Moisture was visible near the cracks on the control section only. Most cracks on the sealed sections looked sealed.

Photo 29: Eckelson Interchange

Photo 30: Eckelson Interchange moisture visible near cracks only in control section

West Sanborn Seperation Bridge

The West Sanborn Separation Bridge had some asphalt streaking on the Degadeck and Radcon sealers where asphalt patching took place on the ends of this bridge deck. This bridge deck also had popouts/spalls on the surface of the concrete which do not appear to be sealed. There was standing water on the TAMMS sealer portion.

Photo 31: West Sanborn Separation Bridge

Sanborn Interchange

Moisture was visible around all cracks and did not appear to be sealed.

Photo 32: Sanborn Interchange

Oakes Interchange

The bridge deck at the Oakes Interchange exhibited wear on the surface due to snowplows. Photo 33 shows the lighter areas in the concrete where the snowplow has taken the sealer off. Moisture was apparent near all large cracks.

Photo 33: Photo of the Oakes interchange facing south

Evaluation

The evaluation period for this project will be 10-years or until additional rehabilitation is required on the structures. Biennial evaluations will be conducted and a report will be generated that documents the performance up to that period.

Items that will be monitored and evaluated are as follows:

- Bridge decks will be chain dragged to find the percentage of delamination prior to the application of the sealers and on a biennial basis.
- Chloride ion content of the concrete will be checked down to 3" prior to the application of the sealers and on a biennial basis.
- Costs and ease of application (at the time of application).

Summary

The bridge evaluations consisted of taking chloride samples, chain dragging the bridge decks, and doing a visual observation of the four bridge decks.

The chloride sampling and chain dragging results are summarized in Tables 6 and 7. At this time it is difficult to draw conclusions to whether or not the products are meeting the manufacturer's performance characteristics.

The Eckelson Interchange was the only bridge deck where the cracks still looked sealed. The West Sanborn Separation Bridge Deck has a lot of old popout/spalls that do not appear to be sealed. The Sanborn Interchange's cracks all showed signs of moisture near the cracks. The bridge deck at the Oakes Interchange exhibited wear on the surface due to snowplows. Also moisture was apparent near all large cracks.

Appendix A: Project Condition Memo From The Bridge Division

MEMORANDUM

TO: Ken Birst
Design Engineer

FROM: Clifford Scott
Preliminary Engineering, Bridge Division

DATE: October 28, 2002

SUBJECT: Project No. IM-2-094(064)275 PCN: 14915
Eckelson to Oakes, WB
Project Concept Report Input

A field review of the project area was conducted on October 17, 2002. This project is scheduled for the March 26, 2004, bid opening. The following structures are within the project limits:

BRIDGE NO.	CROSSING	SIZE	BUILT	SR
94-276.385	Eckelson Int.	210'x24' Bridge	1957	79.3
94-279.636	West Sanborn Sep.	210'x24' Bridge	1958	95.0
94-281.640	Sanborn Int.	210'x24' Bridge	1958	86.1
94-283.139L	Rogers Int.	125'x40' Bridge	1958	92.2
94-284.584L	Hobart Lake Sep.	110'x39' Bridge	1958	96.4
94-288.636	Oakes Int.	220'x30' Bridge	1958	93.1

Bridge No. 94-276.385 (Eckelson Interchange)

This bridge was built in 1957. With the low traffic volume on this structure, the 24' clear deck width meets 3R standards for bridges to remain in place. In 1986, the bridge deck was overlaid, approach slabs were constructed, and free standing rail retrofit was added. The bridge approach railing contains square tubing attached to the bridge railing. The fabric filled slope protection is in good condition. The vertical clearance on the westbound roadway is 16'-8". The superstructure consists of concrete T-beams. It was designed for an H-15 loading and the inventory rating is HS-13. Some cracks are visible on the bridge deck. Also, some minor efflorescence can be seen on the underside of the deck. The Valley City District will chain drag the bridge deck to better evaluate its condition. No work is recommended on the substructure units. If any work is done on the crossroads, the existing bridge rail retrofit should be replaced with one meeting current standards. The cost estimate for this work is as follows:

Bridge rail retrofit (2x210x$35) $15,000

No decision will be made on a possible deck overlay at this time. If this overlay is later recommended, the cost estimate would be increased by about $50,000.

Bridge No. 94-279.636 (West Sanborn Separation)

This bridge was built in 1958. Its roadway width of 24' meets 3R standards for bridges to remain in place. No rehabilitation has been done on this bridge since its construction. The existing bridge rail does not meet current standards and there is no approach railing. There are some spalls and a lot of cracks on the bridge deck. The roadway crossing this bridge is a gravel road. However, there is asphalt for several hundred feet on each end of the bridge. This asphalt is in poor condition. The fabric slope protection is in good condition. The Valley City District will chain drag the bridge deck to better determine its condition. The vertical clearance on the westbound roadway is 16'-7". If any work is done on the crossroads, a bridge rail retrofit is recommended. The cost estimate for this work is as follows:

Bridge rail retrofit (2x210'x$35)	$15,000

If it is determined that a bridge deck overlay is needed, the cost estimate would be about $50,000.

Bridge No. 94-281.640 (Sanborn Interchange)

This bridge was built in 1958. The 24' bridge width meets 3R standards. In 1984, the bridge deck was overlaid and the original bridge railing was replaced with Jersey barrier. As part of the deck overlay, a strip seal was added at the expansion joint in the deck at the center pier. The vertical clearance on the westbound roadway is 16'-9". The fabric filled slope protection is in good condition. There are some cracks in the bridge deck and the gland in the expansion joint is split. The asphalt on the approaches to the bridge is badly cracked. If any work is done on the crossroads, some modifications are needed on the Jersey barriers at the corners of the bridge to accommodate an approved approach guardrail connection. Also, the gland in the strip seal should be replaced. The cost estimate for this work is as follows:

Jersey barrier modifications	$1,000
Strip seal gland	$1,500
Total	$2,500

The Valley City District will chain drag the bridge deck. If it is determined that a bridge deck overlay is needed, the additional cost would be about $50,000.

Bridge No. 94-283.139L (Rogers Interchange)

This bridge was built in 1958 with a concrete curb and a metal 2 tube railing (double beam-Code A). This interchange was made into a full diamond in 1976. At that time, the bridge railing was modified to the E-rail type. In 1979, the bridge deck was overlaid and the bridge approach slabs were replaced. The steel encased concrete piling in the piers were painted in 1991. In the year 2000, the underside of the deck (the bottom of the T-beams) was damaged by an over height load and repaired.

The overlay concrete is badly cracked and an area about 10' wide and 2' long on the east end of the bridge has spalled off. This area has been filled with an asphalt patch. The Valley City District will chain drag the bridge deck to better determine its condition. To correct a settlement problem in the east bridge approach slab, this past summer the Valley City District removed asphalt which had been added and raised the slab using Uretek. This slab appeared to be in good condition at the time of this review. The concrete slope protection is in good condition. A rail retrofit and a new deck overlay are recommended. The cost estimate for this work is as follows:

Deck overlay (125'x40'x1/9x$90)	$50,000
Rail retrofit (2x125'x$35)	$ 9,000
Total	$59,000

Bridge No. 94-284.584L (Hobart Lake Separation)

This bridge was built in 1958 with the double beam-Code A, 2 metal tube bridge railing. In 1979, the bridge deck was overlaid and the bridge approach slabs were removed and replaced. The steel encased concrete piling in the piers were painted in 1991. The original bridge railing has been replaced with Jersey barriers. The bridge now has a clear roadway width of 39.0 feet. The overlay concrete is badly cracked and an area about 2' to 3' long on the east end of the bridge and extending nearly across the entire bridge width has spalled off. This area has been patched with asphalt. The Valley City District will chain drag the bridge deck to better determine its condition. There is no slope protection on the slopes under the bridge. However, these slopes are mostly grassed over and in good condition. The Jersey barriers at the corners of the bridge will have to be modified to accommodate an approved approach rail connection. Because of its condition, a new bridge deck overlay is recommended. The cost estimate for this work is as follows:

Jersey barrier modifications	$ 1,000
Bridge deck overlay (110'x39'x1/9x$90)	$43,000
Total	$44,000

Bridge No. 94-288.636 (Oakes Interchange)

This bridge was built in 1958 and its 30' width meets 3R standards. The vertical clearance on the westbound roadway is 16'-6". The bridge deck was overlaid in 1979. In 1986, bridge approach slabs and a free standing rail retrofit were added. The deck is badly cracked and the joints at the ends of the bridge are spalled. Square tube railing is attached to the bridge railing. The fabric filled slope protection is in good condition. The Valley City District will chain drag the bridge deck to better determine its condition. If any work is done on the crossroads, a new rail retrofit meeting current standards is recommended. The cost estimate is as follows:

Bridge rail retrofit (2x220'x$35)	$15,500

If a bridge deck overlay is determined to be necessary, the cost estimate would be increased by about $66,000

c: Jay Praska, Valley City District

Appendix B: Lab Test Results of Chloride Samples

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck	PROJECT Valley City – Research Project #ND2003-02
LAB NO. M1 – M12	COUNTY Bridge 94-276.385
FIELD SAMPLE NO. E1 – E12	SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A Chloride Content	

DATE RECEIVED	DATE SAMPLED	SUBMITTED BY
10/01/04	07/07/04	B. Fuchs

Lab No.	FS No.	Station Location	Depth, Inches	Chloride Content lb/ cu.yd.
M-1	E-1	19.4' from north end; 6.4' Lt	0.5" – 2.5"	5.11 lb/cu.yd.
M-2	E-2	18.0' from north end; 12.6' Lt	0.5" – 2.5"	7.40 lb/cu.yd.
M-3	E-3	19.7' from north end; 20.6' Lt	0.5" – 2.5"	2.00 lb/cu.yd.
M-4	E-4	74.3' from north end; 3.8' Lt	0.5" – 2.5"	4.70 lb/cu.yd.
M-5	E-5	75.9' from north end; 9.9' Lt	0.5" – 2.5"	4.56 lb/cu.yd.
M-6	E-6	77.5' from north end; 18.1' Lt	0.5" – 2.5"	3.76 lb/cu.yd.
M-7	E-7	124.4' from north end; 3.2' Lt	0.5" – 2.5"	2.23 lb/cu.yd.
M-8	E-8	126.9' from north end; 11.2' Lt	0.5" – 2.5"	3.05 lb/cu.yd.
M-9	E-9	129.3' from north end; 20.3' Lt	0.5" – 2.5"	4.89 lb/cu.yd.
M-10	E-10	184.0' from north end; 4.2' Lt	0.5" – 2.5"	4.38 lb/cu.yd.
M-11	E-11	184.7' from north end; 14.1' Lt	0.5" – 2.5"	9.28 lb/cu.yd.
M-12	E-12	187.0' from north end; 21.1' Lt	0.5" – 2.5"	4.42 lb/cu.yd.

Date: January 26, 2006

Scott W. Wutzke

Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Bryon Fuchs

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck	PROJECT Valley City – Research Project #ND2003-02
LAB NO. CL181 – CL192	COUNTY Bridge 94-276.385
FIELD SAMPLE NO. E1 – E12	SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A Chloride Content	

DATE RECEIVED	DATE SAMPLED	SUBMITTED BY
05/07/08	05/06/08	Andrew Mastel

Lab No.	FS No.	Station Location	Depth, Inches	Chloride Content lb/ cu.yd.
CL-181	E-1	19.4' from north end; 6.4' Lt	0.5" – 2.5"	3.80 lb/cu.yd.
CL-182	E-2	18.0' from north end; 12.6' Lt	0.5" – 2.5"	4.97 lb/cu.yd.
CL-183	E-3	19.7' from north end, 20.6' Lt	0.5" – 2.5"	1.68 lb/cu.yd.
CL-184	E-4	74.3' from north end; 3.8' Lt	0.5" – 2.5"	3.48 lb/cu.yd.
CL-185	E-5	75.9' from north end; 9.9' Lt	0.5" – 2.5"	3.92 lb/cu.yd.
CL-186	E-6	77.5' from north end; 18.1' Lt	0.5" – 2.5"	4.66 lb/cu.yd.
CL-187	E-7	124.4' from north end; 3.2' Lt	0.5" – 2 5"	1.06 lb/cu.yd.
CL-188	E-8	126.9' from north end; 11.2' Lt	0.5" – 2.5"	1.37 lb/cu.yd.
CL-189	E-9	129.3' from north end; 20.3' Lt	0.5" – 2.5"	2.54 lb/cu.yd.
CL-190	E-10	184 0' from north end; 4.2' Lt	0.5" – 2.5"	4.68 lb/cu.yd.
CL-191	E-11	184.7' from north end; 14.1' Lt	0.5" – 2.5"	3.21 lb/cu.yd.
CL-192	E-12	187.0' from north end; 21.1' Lt	0.5" – 2.5"	2.62 lb/cu.yd.

Date: March 25, 2009

Scott W. Wutzke

Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Andrew Mastel

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck		PROJECT Valley City – Research Project #ND2003-02
LAB NO. M13 - M24		COUNTY Bridge 94-279.636
FIELD SAMPLE NO. WS1 – WS12		SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A Chloride Content		
DATE RECEIVED 10/01/04	DATE SAMPLED 07/07/04	SUBMITTED BY B. Fuchs

Lab No.	FS No.	Station Location	Depth	Chloride Content lb/cu.yd.
M-13	WS-1	26.4' from north end; 3.4' Lt	0.5" – 2.5"	0.59 lb/cu.yd.
M-14	WS -2	29.0' from north end; 10.8' Lt	0.5" – 2.5"	1.10 lb/cu.yd.
M-15	WS -3	29.5' from north end; 19.7' Lt	0.5" – 2.5"	0.74 lb/cu.yd.
M-16	WS -4	77.9' from north end; 7.8' Lt	0.5" – 2.5"	2.51 lb/cu.yd.
M-17	WS -5	88.6' from north end; 11.5' Lt	0.5" – 2.5"	0.74 lb/cu.yd.
M-18	WS -6	87.8' from north end; 20.5' Lt	0.5" – 2.5"	0.70 lb/cu.yd.
M-19	WS -7	134.1' from north end; 3.8' Lt	0.5" – 2.5"	0.78 lb/cu.yd.
M-20	WS -8	137.9' from north end; 10.5' Lt	0.5" – 2.5"	1.21 lb/cu.yd.
M-21	WS -9	135.5' from north end; 20.2' Lt	0.5" – 2.5"	1.10 lb/cu.yd.
M-22	WS -10	176.8' from north end; 5.4' Lt	0.5" – 2.5"	0.59 lb/cu.yd.
M-23	WS -11	176.6' from north end; 11.2' Lt	0.5" – 2.5"	0.63 lb/cu.yd.
M-24	WS -12	177.7' from north end; 20.2' Lt	0.5" – 2.5"	0.84 lb/cu.yd.

Date: January 26, 2006

Scott W. Wutzke

Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Bryon Fuchs

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck	PROJECT Valley City – Research Project #ND2003-02
LAB NO. CL193 - CL204	COUNTY Bridge 94-279.636
FIELD SAMPLE NO. WS1 – WS12	SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A Chloride Content	

DATE RECEIVED	DATE SAMPLED	SUBMITTED BY
05/07/08	05/06/08	Andrew Mastel

Lab No.	FS No.	Station Location	Depth	Chloride Content lb/cu.yd.
CL-193	WS-1	26.4' from north end; 3.4' Lt	0.5" – 2.5"	0.98 lb/cu.yd.
CL-194	WS -2	29.0' from north end; 10.8' Lt	0.5" – 2.5"	0.98 lb/cu.yd.
CL-195	WS -3	29.5' from north end; 19.7' Lt	0.5" – 2.5"	0.86 lb/cu.yd.
CL-196	WS -4	77.9' from north end; 7.8' Lt	0.5" – 2.5"	0.43 lb/cu.yd.
CL-197	WS -5	88.6' from north end; 11.5' Lt	0.5" – 2.5"	0.70 lb/cu.yd
CL-198	WS -6	87.8' from north end; 20.5' Lt	0.5" – 2.5"	0.39 lb/cu.yd.
CL-199	WS -7	134.1' from north end; 3.8' Lt	0.5" – 2.5"	0.43 lb/cu.yd.
CL-200	WS -8	137.9' from north end; 10.5' Lt	0.5" – 2.5"	0.74 lb/cu.yd.
CL-201	WS -9	135.5' from north end; 20.2' Lt	0.5" – 2.5"	0.82 lb/cu.yd.
CL-202	WS -10	176.8' from north end; 5.4' Lt	0.5" – 2.5"	0.82 lb/cu.yd.
CL-203	WS -11	176.6' from north end; 11.2' Lt	0.5" – 2.5"	0 86 lb/cu.yd.
CL-204	WS -12	177.7' from north end; 20.2' Lt	0.5" – 2.5"	1.14 lb/cu.yd.

Date: March 25, 2009

Scott W. Wutzke

Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Andrew Mastel

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck		PROJECT Valley City – Research Project #ND2003-02
LAB NO. M25 – M36		COUNTY Bridge 94-281.640
FIELD SAMPLE NO. S1 - S12		SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A		
DATE RECEIVED 10/01/04	DATE SAMPLED 07/07/04	SUBMITTED BY B. Fuchs

Lab No.	FS No.	Station Location	Depth	Chloride Content lb/cu.yd.
M-25	S-1	27.8' from north end; 2.5' Lt	0.5" – 2.5"	3.09 lb/cu.yd.
M-26	S -2	27.9' from north end; 10.7' Lt	0.5" – 2.5"	2.11 lb/cu.yd.
M-27	S -3	33.2' from north end; 21.6' Lt	0.5" – 2.5"	5.32 lb/cu.yd.
M-28	S -4	76.2' from north end; 3.6' Lt	0.5" – 2.5"	2.58 lb/cu.yd.
M-29	S -5	76.0' from north end; 11.2' Lt	0.5" – 2.5"	0.74 lb/cu.yd.
M-30	S -6	75.9' from north end; 21.8' Lt	0.5" – 2.5"	3.25 lb/cu.yd.
M-31	S -7	134.5' from north end; 4.3' Lt	0.5" – 2.5"	1.02 lb/cu.yd.
M-32	S -8	135.6' from north end; 10.2' Lt	0.5" – 2.5"	1.02 lb/cu.yd.
M-33	S -9	135.6' from north end; 20.9' Lt	0.5" – 2.5"	6.77 lb/cu.yd.
M-34	S -10	185.0' from north end; 3.4' Lt	0.5" – 2.5"	2.19 lb/cu.yd.
M-35	S -11	188.6' from north end; 11.2' Lt	0.5" – 2.5"	1.61 lb/cu.yd.
M-36	S -12	189.0' from north end; 21.0' Lt	0.5" – 2.5"	2.76 lb/cu.yd.

Date: January 26, 2006

Scott W. Wutzke

Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Bryon Fuchs

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck	PROJECT Valley City – Research Project #ND2003-02
LAB NO. CL205 – CL216	COUNTY Bridge 94-281.640
FIELD SAMPLE NO. S1 - S12	SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A	

DATE RECEIVED	DATE SAMPLED	SUBMITTED BY
05/07/08	05/06/08	Andrew Mastel

Lab No.	FS No.	Station Location	Depth	Chloride Content lb/cu.yd.
CL-205	S-1	27.8' from north end; 2.5' Lt	0 5" – 2.5"	2.04 lb/cu.yd.
CL-206	S -2	27.9' from north end; 10.7' Lt	0.5" – 2.5"	1.25 lb/cu.yd.
CL-207	S -3	33.2' from north end, 21.6' Lt	0.5" – 2.5"	4.54 lb/cu.yd.
CL-208	S -4	76.2' from north end; 3.6' Lt	0.5" – 2.5"	2.74 lb/cu.yd.
CL-209	S -5	76.0' from north end; 11.2' Lt	0.5" – 2.5"	1.37 lb/cu.yd.
CL-210	S -6	75.9' from north end; 21.8' Lt	0.5" – 2.5"	3.48 lb/cu.yd.
CL-211	S -7	134.5' from north end; 4.3' Lt	0 5" – 2.5"	0.94 lb/cu.yd.
CL-212	S -8	135.6' from north end; 10.2' Lt	0.5" – 2.5"	1.06 lb/cu.yd.
CL-213	S -9	135.6' from north end; 20.9' Lt	0.5" – 2.5"	8.10 lb/cu.yd.
CL-214	S -10	185.0' from north end; 3 4' Lt	0.5" – 2.5"	2.27 lb/cu.yd.
CL-215	S -11	188.6' from north end; 11.2' Lt	0.5" – 2.5"	0 90 lb/cu.yd.
CL-216	S -12	189.0' from north end; 21.0' Lt	0.5" – 2.5"	3.29 lb/cu.yd.

Date. March 25, 2009

Scott W. Wutzke

Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Andrew Mastel

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck		PROJECT Valley City – Research Project #ND2003-02
LAB NO. M37 – M48		COUNTY Bridge 94-288.636
FIELD SAMPLE NO. O1 - O12		SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A		
DATE RECEIVED 10/01/04	DATE SAMPLED 07/07/04	SUBMITTED BY B. Fuchs

Lab No.	FS No.	Station Location	Depth	Chloride Content lb/cu.yd.
M-37	O-1	26.5' from north end; 4.1' Lt	0.5" – 2.5"	3.76 lb/cu.yd.
M-38	O-2	25.9' from north end; 12.8' Lt	0.5" – 2.5"	5.91 lb/cu.yd.
M-39	O-3	26.9' from north end; 25.6' Lt	0.5" – 2.5"	11.67 lb/cu.yd.
M-40	O-4	67.5' from north end; 5.1' Lt	0.5" – 2.5"	4.66 lb/cu.yd.
M-41	O-5	68.1' from north end; 13.4' Lt	0.5" – 2.5"	4.78 lb/cu.yd.
M-42	O-6	69.2' from north end; 27.8' Lt	0.5" – 2.5"	5.89 lb/cu.yd.
M-43	O-7	132.7' from north end; 2.6' Lt	0.5" – 2.5"	2.35 lb/cu.yd.
M-44	O-8	130.0' from north end; 17.1' Lt	0.5" – 2.5"	9.55 lb/cu.yd.
M-45	O-9	131.8' from north end; 27.2' Lt	0.5" – 2.5"	10.57 lb/cu.yd.
M-46	O-10	204.6' from north end; 5.4' Lt	0.5" – 2.5"	2.19 lb/cu.yd.
M-47	O-11	205.6' from north end; 13.7' Lt	0.5" – 2.5"	11.43 lb/cu.yd.
M-48	O-12	207.1' from north end; 27.0' Lt	0.5" – 2.5"	13.53 lb/cu.yd.

Date: January 26, 2006

Scott W. Wutzke

Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Bryon Fuchs

REPORT OF TEST ON SAMPLE

Department of Transportation, Materials & Research

MATERIAL Pulverized PCC from Bridge Deck	PROJECT Valley City – Research Project #ND2003-02
LAB NO. CL217 – CL228	COUNTY Bridge 94-288.636
FIELD SAMPLE NO. O1 - O12	SAMPLE FROM Deck locations & sample depths listed below
SPECIFICATION AASHTO T-260-97 Chloride Content, Procedure A	

DATE RECEIVED	DATE SAMPLED	SUBMITTED BY
05/07/08	05/06/08	Andrew Mastel

Lab No.	FS No.	Station Location	Depth	Chloride Content lb/cu.yd.
CL-217	O-1	26.5' from north end; 4.1' Lt	0.5" – 2.5"	6.15 lb/cu.yd.
CL-218	O-2	25.9' from north end; 12.8' Lt	0.5" – 2.5"	3.25 lb/cu.yd.
CL-219	O-3	26.9' from north end; 25.6' Lt	0.5" – 2.5"	4.93 lb/cu.yd.
CL-220	O-4	67.5' from north end; 5.1' Lt	0.5" – 2.5"	3.60 lb/cu.yd.
CL-221	O-5	68.1' from north end; 13.4' Lt	0.5" – 2.5"	2.19 lb/cu.yd.
CL-222	O-6	69.2' from north end; 27.8' Lt	0.5" – 2.5"	5.60 lb/cu.yd.
CL-223	O-7	132.7' from north end; 2.6' Lt	0.5" – 2.5"	5.79 lb/cu.yd.
CL-224	O-8	130.0' from north end; 17.1' Lt	0.5" – 2.5"	6.54 lb/cu.yd.
CL-225	O-9	131.8' from north end; 27.2' Lt	0.5" – 2.5"	6.26 lb/cu.yd.
CL-226	O-10	204.6' from north end; 5.4' Lt	0 5" – 2.5"	1.96 lb/cu.yd.
CL-227	O-11	205.6' from north end; 13.7' Lt	0.5" – 2.5"	7.13 lb/cu.yd.
CL-228	O-12	207.1' from north end; 27.0' Lt	0.5" – 2.5"	10.94 lb/cu yd.

Date: March 25, 2009

Scott W. Wutzke

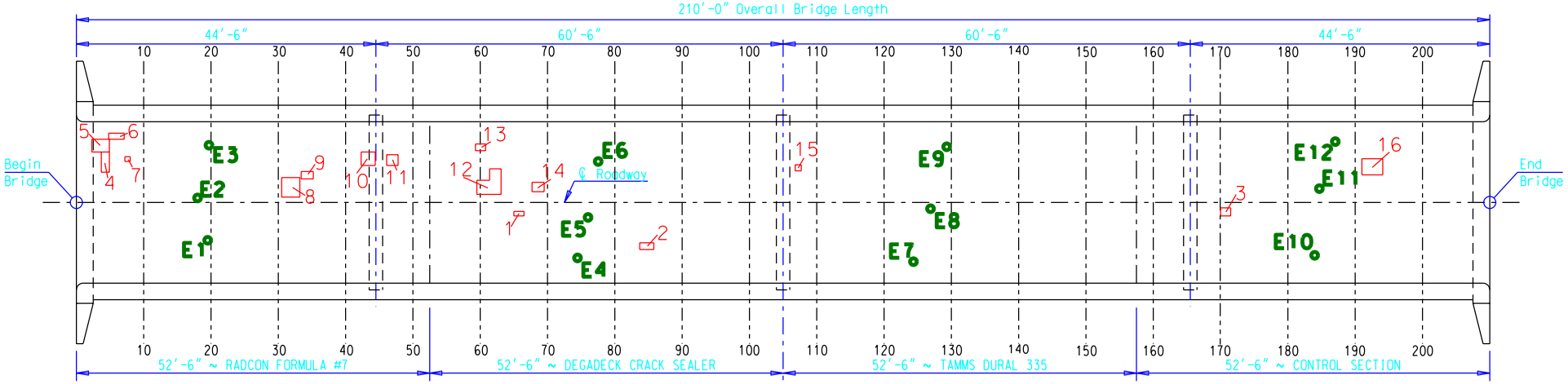
Laboratory Supervisor

Distribution:

Central Laboratory
Ryan Johnson
Andrew Mastel

Appendix C: Delamination and Chloride Test Locations

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



Bridge Deck Area = 5,040 ft^2	2004
Delamination Number	Area (ft^2)
1	1.1
2	2.1
3	1.8
4	3.6
5	4.9
6	2.1
7	0.6
8	7.8
9	2.0
10	4.2
11	2.7
12	6.5
13	1.5
14	2.5
15	0.8
16	7.4
Total =	51.6
Total Delamination of Deck =	1.0%

□ = 2004 delamination areas

○ = 2004 chloride test holes

Eckleson Interchange 94-276.385

2004 DELAMINATION AREAS, TEST HOLE LOCATIONS, AND SEALANT LOCATIONS

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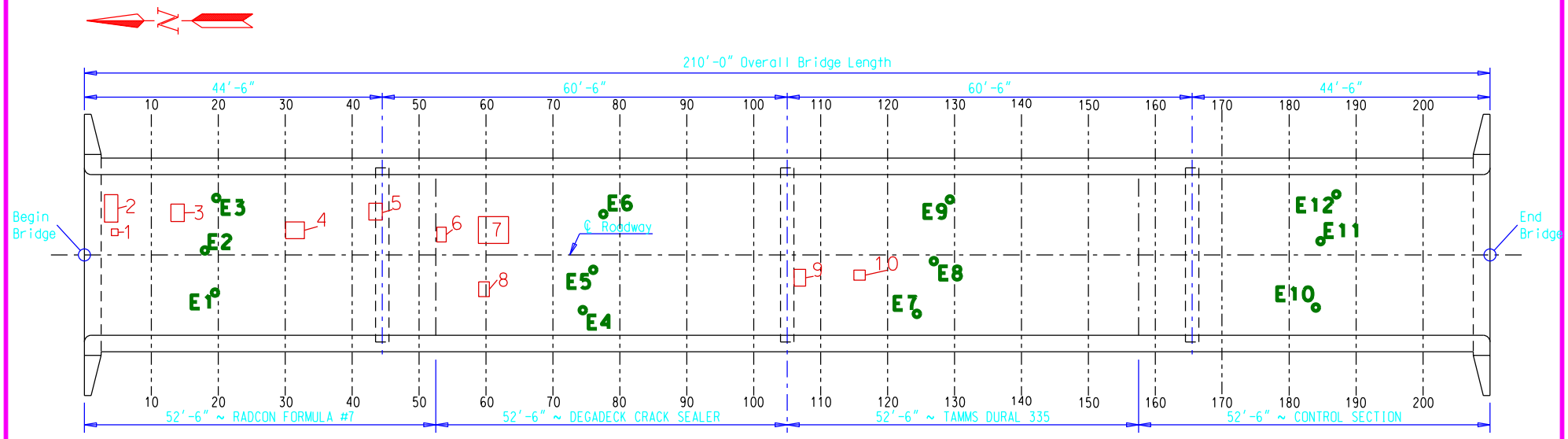
STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



PLAN

Bridge Deck Area = 5,040 ft^2	2008
Delamination Number	Area (ft^2)
1	1.0
2	8.2
3	5.2
4	7.0
5	5.0
6	3.1
7	18.0
8	3.5
9	4.3
10	2.6
Total =	57.9
Total Delamination of Deck =	1.1%

□ = 2008 delamination areas

○ = 2008 chloride testing holes

ECKELSON INTERCHANGE 94-276.385

2008 DELAMINATION AREAS, APPROXIMATE TEST HOLE LOCATIONS, AND SEALANT LOCATIONS

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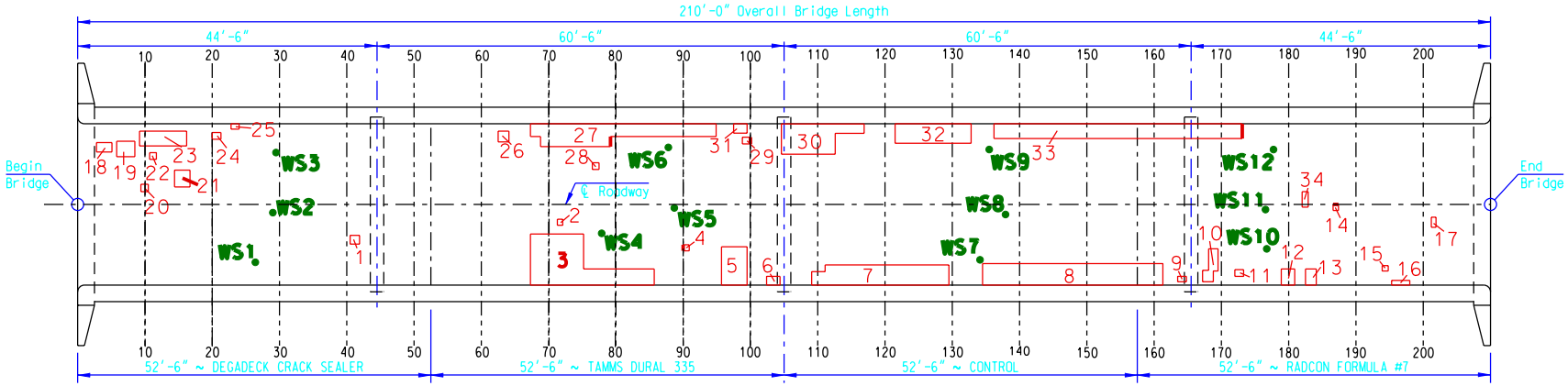
STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



Bridge Deck Area = 5,040 ft^2	2004
Delamination Number	Area (ft^2)
1	1.8
2	0.7
3	85.2
4	0.8
5	21.7
6	2.6
7	59.2
8	85.8
9	1.0
10	7.3
11	1.3
12	4.8
13	3.8
14	0.7
15	0.7
16	1.9
17	1.0
18	3.2

Bridge Deck Area = 5,040 ft^2	2004
Delamination Number	Area (ft^2)
19	6.2
20	1.2
21	5.8
22	1.0
23	15.4
24	1.3
25	1.0
26	2.6
27	68.0
28	1.0
29	1.2
30	42.0
31	2.8
32	32.8
33	81.2
34	2.1
Total =	549.1
Total Delamination of Deck =	10.9%

□ = 2004 delamination areas

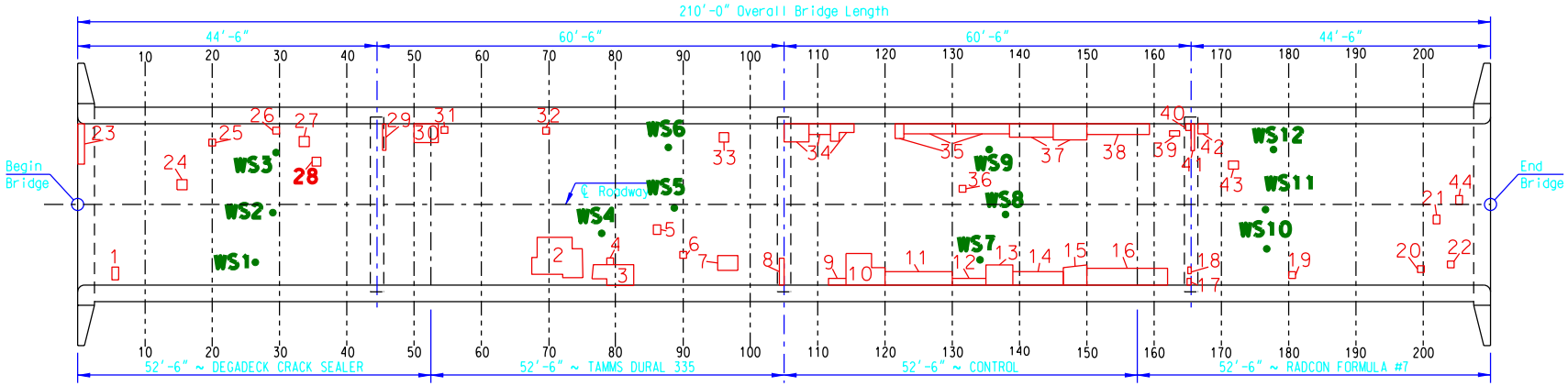
● = 2004 chloride testing holes

WEST SANBORN SEPERATION 94-279.636

2004 DELAMINATION AREAS, TEST HOLE LOCATIONS, AND SEALANT LOCATIONS

3/12/2009 Z:\LAB\RESEARCH\Research Projects\ND Research Projects\ND03-02\West Sanborn2008.dgn

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



Bridge Deck Area = 5,040 ft^2	2008
Delamination Number	Area (ft^2)
1	1.9
2	36.9
3	17.0
4	1.0
5	1.5
6	1.0
7	6.6
8	2.8
9	2.6
10	24.2
11	20.0
12	5.0
13	12.0
14	15.0
15	9.5
16	30.0
17	0.6
18	0.5
19	1.0
20	1.0
21	1.3
22	1.0
23	6.0

Bridge Deck Area = 5,040 ft^2	2008
Delamination Number	Area (ft^2)
24	2.2
25	1.0
26	1.0
27	2.3
28	1.7
29	2.0
30	10.1
31	1.0
32	1.0
33	2.8
34	22.2
35	27.2
36	1.0
37	24.7
38	14.9
39	1.2
40	0.8
41	2.0
42	2.3
43	1.8
44	1.3
Total =	322.9
Total Delamination of Deck =	6.4%

□ = 2008 delamination areas

● = 2008 chloride testing holes

WEST SANBORN SEPERATION 94-279.636

2008 DELAMINATION AREAS, TEST HOLE LOCATIONS, AND SEALANT LOCATIONS

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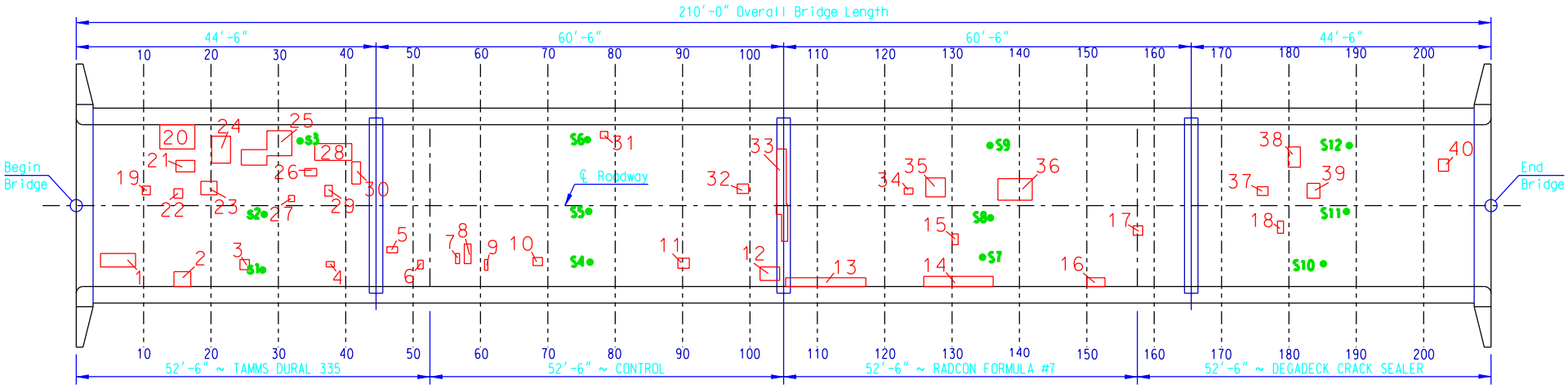
STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



Bridge Deck Area = 5,040 ft^2	2004
Delamination Number	Area (ft^2)
1	10.4
2	5.5
3	2.1
4	1.0
5	1.4
6	1.0
7	0.9
8	2.9
9	0.8
10	1.7
11	2.6
12	5.8
13	15.5
14	15.5
15	1.5
16	3.5
17	2.0
18	1.6
19	1.6
20	18.7
21	4.8

Bridge Deck Area = 5,040 ft^2	2004
Delamination Number	Area (ft^2)
22	1.8
23	4.8
24	11.2
25	22.4
26	2.0
27	0.8
28	13.8
29	1.8
30	4.3
31	1.1
32	2.4
33	17.6
34	1.2
35	8.1
36	16.3
37	2.1
38	5.4
39	4.2
40	2.7
Total =	224.8
Total Delamination of Deck =	4.5%

☐ =2004 delamination areas

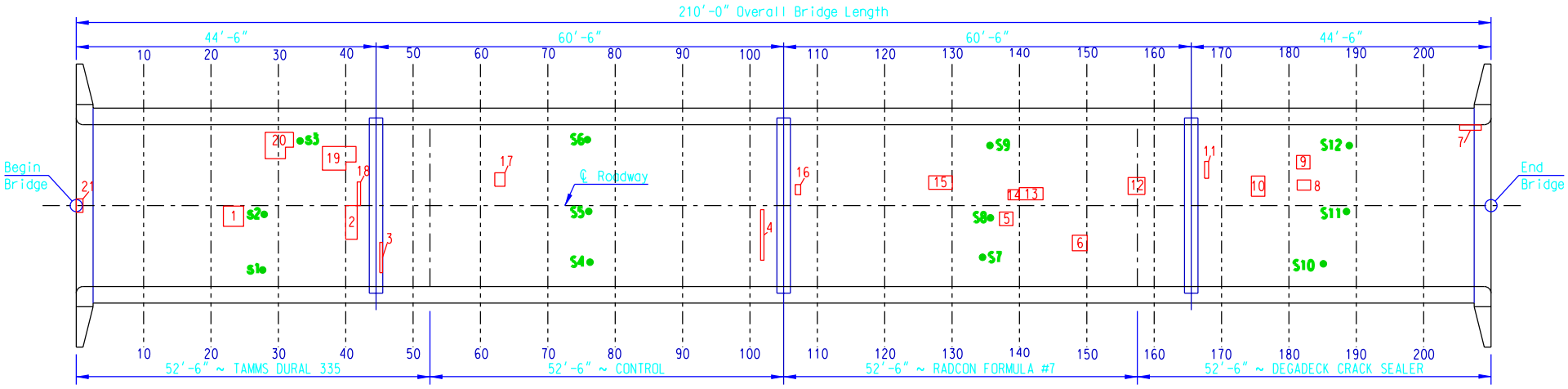
● =2004 chloride testing location

Sandborn Interchange 94-281.640

2004 DELAMINATION AREAS, TEST HOLE LOCATIONS, AND SEALANT LOCATIONS

3/12/2009 Z:\LAB\RESEARCH\Research Projects\ND Research Projects\ND03-02\Sanborn.dgn

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



Bridge Deck Area = 5,040 ft^2	2008
Delamination Number	Area (ft^2)
1	9.0
2	8.5
3	1.8
4	3.8
5	4.0
6	5.1
7	2.6
8	3.0
9	4.0
10	6.0
11	1.5
12	6.3
13	6.3
14	2.6
15	7.0
16	1.2
17	3.0
18	1.8
19	15.7
20	13.5
21	2.0
Total =	108.4
Total Delamination of Deck =	2.2%

☐ =2008 delamination areas

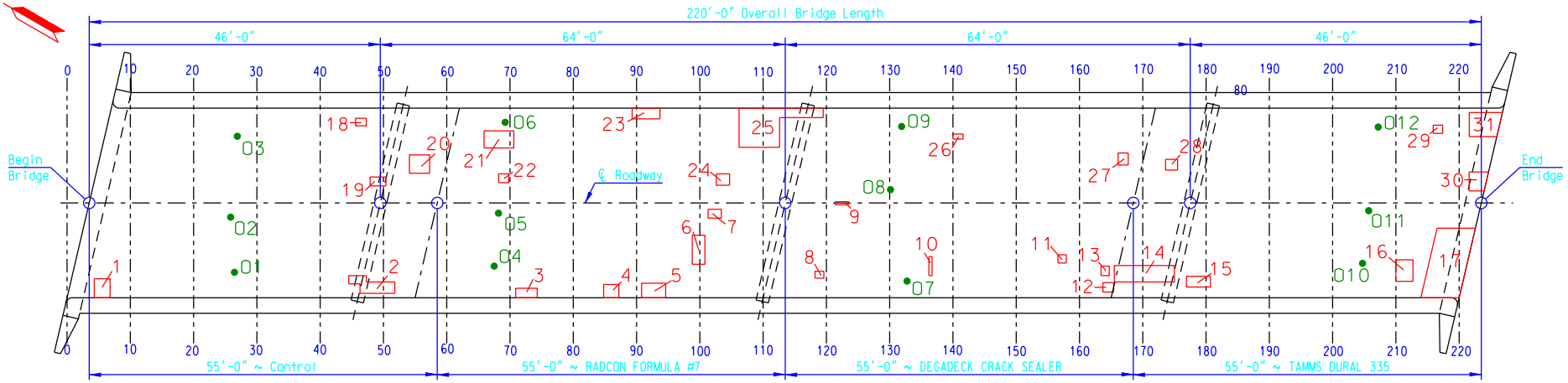
● =2008 chloride testing location

Sandborn Interchange 94-281.640

2008 DELAMINATION AREAS, TEST HOLE LOCATIONS, AND SEALANT LOCATIONS

3/3/2009 Z:\LAB\RESEARCH\Research Projects\ND Research Projects\ND03-02\Sanborn2004.dgn

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



Bridge Deck Area = 6,600 ft^2	2004
Delamination Number	Area (ft^2)
1	7.5
2	13.2
3	5.1
4	5.0
5	8.7
6	9.2
7	2.9
8	1.5
9	1.1
10	1.5
11	1.7
12	2.6
13	2.0
14	24.7
15	6.5
16	9.2
17	66.6

Bridge Deck Area = 6,600 ft^2	2004
Delamination Number	Area (ft^2)
18	2.0
19	3.5
20	9.3
21	12.7
22	2.2
23	7.5
24	3.8
25	50.0
26	1.3
27	3.0
28	3.2
29	2.0
30	8.1
31	18.2
Total =	295.8
Total Delamination of Deck =	4.5%

□ =2004 delamination areas
● =2004 chloride testing location

OAKES INTERCHANGE 94-288.636

2004 DELAMINATION AREAS, TEST HOLE LOCATIONS, AND SELANT LOCATIONS

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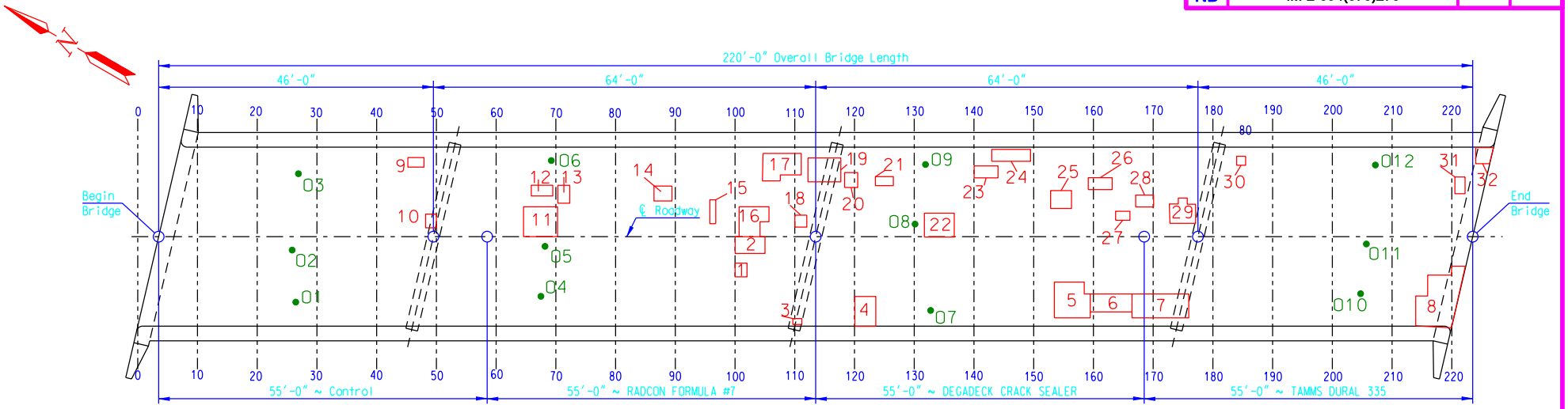
STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	IM-2-094(070)275	·	·



Bridge Deck Area = 6,600 ft^2	2008
Delamination Number	Area (ft^2)
1	4.6
2	14.0
3	1.5
4	17.5
5	33.2
6	21.0
7	38.0
8	58.4
9	4.0
10	4.1
11	28.5
12	6.5
13	6.0
14	7.5
15	4.0
16	21.3
17	26.0

Bridge Deck Area = 6,600 ft^2	2008
Delamination Number	Area (ft^2)
18	4.0
19	22.0
20	5.5
21	4.5
22	20.0
23	8.0
24	13.0
25	10.5
26	8.0
27	3.9
28	6.0
29	16.4
30	2.3
31	4.8
32	6.21
Total =	431.1
Total Delamination of Deck =	6.5%

□ =2008 delamination areas
● =2008 chloride testing location

OAKES INTERCHANGE 94-288.636

2008 DELAMINATION AREAS, TEST HOLE LOCATIONS, AND SELANT LOCATIONS

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Appendix D: Traffic

ESTIMATE OF CURRENT AND FUTURE TRAFFIC
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
(PLANNING DIV. TRAFFIC INFO. SECTION)

RECNO: 4443 ***PCN:***

DATE PRINTED OR REPRINTED: 5/3/2005 ***PROJECT NO:***

DATE PREPARED: 11/25/2002 ***COUNTY:*** ***ROUTE ID:*** 0

HIGHWAY NO: 94 ***HWY SUFFIX:***

REF PT: 276.000 ***FR OFFSET:*** 0.0000 ***LENGTH:***

PASS EXPANSION FACTOR: 1.10 ***TRUCK EXPANSION FACTOR:*** 1.10

TRAFFIC'S ANNUAL % OF GROWTH: 0.5 ***ESALS ANNUAL % OF GROWTH:*** 0.5

LOCATION: I-94 ECKELSON INTERCHANGE RP 276.555 ECKELSON INTERCHANGE OVERHEAD ONLY

**** * * * * * * * ALL AADT'S ESALS, ARE AT THE HIGHEST POINT OF THE PROJECT SEGMENT * * * * * * ****

	YEAR	PASS	TRUCKS	TOTAL	30TH MAX HR	E.S.A.L.'S FLEX	E.S.A.L.'S RIGID
CURRENT	2002	320	30	350	35	20	35
FORECAST	2022	350	40	390	40	30	45

* *

PAVEMENT EQUIVALENCY FACTORS: FLEXIBLE AT SN 4 RIGID AT 9 INCHES

WAS CLASS WIM DATA AVAILABLE FOR THIS PARTICULAR LOCATION? Y

IS THIS A REVISED ESTIMATE? N ***SUPERCEDES EST. OF***

REQUESTED BY: BRYON FUCHS - TRAFFIC IS BOTH DIRECTIONS

REMARKS:

ESTIMATE OF CURRENT AND FUTURE TRAFFIC
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
(PLANNING DIV. TRAFFIC INFO. SECTION)

RECNO: 4446

PCN:

DATE PRINTED OR REPRINTED: 5/3/2005

PROJECT NO:

DATE PREPARED: 11/25/2002

COUNTY:

ROUTE ID: 0

HIGHWAY NO: 94 ***HWY SUFFIX:***

REF PT: 281.000 ***FR OFFSET:*** 0.0000 ***LENGTH:***

PASS EXPANSION FACTOR: 1.10

TRUCK EXPANSION FACTOR: 1.10

TRAFFIC'S ANNUAL % OF GROWTH: 0.5

ESALS ANNUAL % OF GROWTH: 0.5

LOCATION: I-94 AND SANBORN INTERCHANGE, RP 281.640 SANBORN INTERCHANGE OVERHEAD ONLY

***** * * * * * * * ALL AADT'S ESALS, ARE AT THE HIGHEST POINT OF THE PROJECT SEGMENT * * * * * * ****

	YEAR	PASS	TRUCKS	TOTAL	30TH MAX HR	E.S.A.L.'S FLEX	E.S.A.L.'S RIGID
CURRENT	2002	370	30	400	40	25	40
FORECAST	2022	410	40	450	45	30	50

* *

PAVEMENT EQUIVALENCY FACTORS: ***FLEXIBLE AT SN 4*** ***RIGID AT 9 INCHES***

WAS CLASS WIM DATA AVAILABLE FOR THIS PARTICULAR LOCATION? Y

IS THIS A REVISED ESTIMATE? N ***SUPERCEDES EST. OF***

REQUESTED BY: BRYON FUCHS - TRAFFIC IS BOTH DIRECTIONS

REMARKS:

ESTIMATE OF CURRENT AND FUTURE TRAFFIC
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
(PLANNING DIV. TRAFFIC INFO. SECTION)

RECNO: 4455 ***PCN:***

DATE PRINTED OR REPRINTED: 5/3/2005 ***PROJECT NO:***

DATE PREPARED: 11/25/2002 ***COUNTY:*** ***ROUTE ID:*** 0

HIGHWAY NO: 94 ***HWY SUFFIX:***

REF PT: 288.000 ***FR OFFSET:*** 0.0000 ***LENGTH:***

PASS EXPANSION FACTOR: 1.10 ***TRUCK EXPANSION FACTOR:*** 1.10

TRAFFIC'S ANNUAL % OF GROWTH: 0.5 ***ESALS ANNUAL % OF GROWTH:*** 0.5

LOCATION: I-94 AND OAKES INTERCHANGE, RP 288.636 OAKES INTERCHANGE OVERHEAD ONLY

**** * * * * * * * ALL AADT'S ESALS, ARE AT THE HIGHEST POINT OF THE PROJECT SEGMENT * * * * * * ****

	YEAR	PASS	TRUCKS	TOTAL	30TH MAX HR	E.S.A.L.'S FLEX	E.S.A.L.'S RIGID
CURRENT	2002	740	150	890	90	110	175
FORECAST	2022	815	165	980	100	120	195

* *

PAVEMENT EQUIVALENCY FACTORS: ***FLEXIBLE AT SN 4*** ***RIGID AT 9 INCHES***

WAS CLASS WIM DATA AVAILABLE FOR THIS PARTICULAR LOCATION? Y

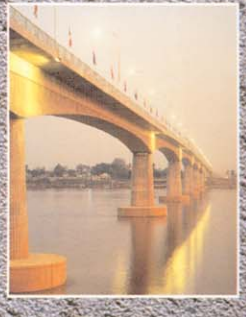
IS THIS A REVISED ESTIMATE? N ***SUPERCEDES EST. OF***

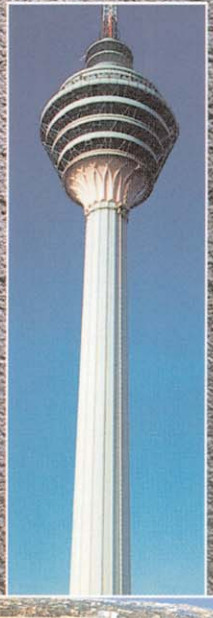
REQUESTED BY: BRYON FUCHS - TRAFFIC IS BOTH DIRECTIONS

REMARKS:

Appendix E: Radcon Formula #7 Literature

RADCON®
FORMULA #7





PROVEN PERFORMANCE SINCE 1975 RADCON FORMULA #7

At the forefront of concrete waterproofing and protection©

WHY RADCON #7 ?

With **Radcon Formula #7**'s progressive growth dating back to 1975, the product has built an undisputable track record over some 25+ countries. The acceptance of **Radcon Formula #7**® has been driven by the product's unique performance on-site, leading now to its' use on projects of global prominence.

Radcon Formula #7® is not a surface coating, admixture, crystal growth, or water repellent. It is a biochemically modified solution that is spray applied to cured concrete. Through a 3 day watering process, the product penetrates and reacts with the concrete forming a sub-surface barrier, waterproofing pores, capillaries and large cracks against the ingress of water and contaminants.

The philosophy behind **Radcon Formula #7**® is that the product works with the concrete, as concrete does have some inherent waterproofing capability. By doing this **Radcon Formula #7**® makes the concrete waterproof, both through the matrix and most importantly sealing cracks. Tradition has been to introduce another variable into the waterproofing equation, that being a membrane to cover up the concrete. Then, to protect the membrane from environmental and mechanical damage a protective screed is often required, thus introducing another variable.

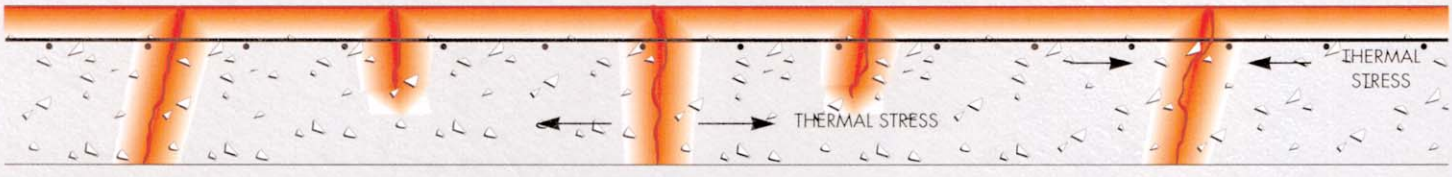
During construction, any surface coating becomes vulnerable to damage from other trades. The problem which arises from this traditional approach, may not necessarily be realised immediately. If and when leakage does occur then fault finding and remedial action can be a monumental task, with water tracking beneath the screed and/or membrane.

Alternatively, **Radcon Formula #7**® is applied to concrete with pre-formed fall lines thus eliminating the need for protective screeds. As there is only one waterproofing variable, the concrete, in the advent of a leakage during the life of the structure, repair is performed directly to the concrete. Even with this being the case, waterproofing will never substitute good engineering practice of quality concreting, adequate jointing and detailing.

WHAT MAKES RADCON #7 DIFFERENT?

The unique features of **Radcon Formula #7**® relate to it's silicate composition which has been biochemically modified. Firstly, the product will permanently waterproof existing leaking cracks in concrete up to 2.00mm, even when exposed to typical high thermal stresses on rooftops. Secondly, the product that has absorbed into the concrete matrix remains active to seal new hairline cracks on contact with water. This phenomenon has been confirmed on applications in areas of earthquake activity.

WHAT RADCON #7 DOES.



BENEFITS

FAST

The application rate with one motorised spray unit ranges up to 800 sqm per hour. This enables relatively quick product application to fast-track projects.

EASE OF APPLICATION

Although the product requires a level of technical competence, it is easy to apply. At the end of the application this can easily be tested by ponding the treated area.

TRAFFICABLE (AFTER 1ST WATERING)

After the first watering is completed, at approximately 6 hours after product application, the site becomes completely trafficable. This increases site time efficiency and reduces risk of damage from other trades during construction.

OUT-GASSING

In humid environments trapped moisture in concrete often leads to premature delamination of membranes. Alternatively, **Radcon Formula #7**® still enables the concrete to out-gas moisture eliminating this problem.

In freeze/thaw environments, **Radcon Formula #7**® significantly reduces moisture absorption into the matrix and seals cracks increasing the concrete's durability in this harsh environment. The out-gassing also allows moisture to evaporate out of the concrete reducing freeze-thaw damage.

NON-TOXIC

Radcon Formula #7® is water-based. Equipment can easily be cleaned and the product can be safely handled on-site.

COMPLETE WATERPROOFING
(MATRIX, CRACKS AND FUTURE HAIRLINE CRACKING)

Radcon Formula #7® is a complete replacement for a membrane as it waterproofs both the concrete matrix, and cracks even when exposed to high thermal stresses. The penetrated product remains reactive in the presence of water to provide autogenous healing capabilities to future hairline cracking.

RISK MANAGEMENT

Radcon Formula #7® is applied directly to structural concrete with no requirement for a protective screed - one waterproofing variable. Thus, if, at any stage of the building's life, a leakage occurs it can be repaired quickly and easily with no tracking beneath a membrane or screed. This approach drastically reduces the cost of ongoing maintenance with no removal of membranes or toppings.

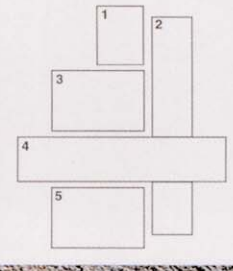
PROVEN PERFORMANCE

With product applications dating back to 1975, **Radcon Formula #7**® has developed an enviable track record, based on successful long term performance. **Radcon Formula #7**® is available across some 25+ countries and now waterproofing sites of global recognition.

PRODUCT DESCRIPTION

Radcon Formula #7® is a biochemically modified silicate solution that provides long-term waterproofing and durability benefits to concrete. It penetrates into concrete and reacts with free calcium and water to form a non-water soluble calcium silicate hydrate gel complex in cracks, pores and capillaries. This gel creates a sub-surface barrier against the ingress of water and contaminants such as chloride ions.

Radcon Formula #7® will seal existing leaking cracks up to 2.00mm. In the matrix the product remains reactive when in contact with water to provide autogenous healing properties to future hairline cracks.



FRONT PAGE

1. Mekong River (Friendship) Bridge, Thailand/Laos
2. Kuala Lumpur Telecommunications Tower
3. Australian Taxation Office, Hurstville, Sydney
4. Seacon Square Shopping Centre, Bangkok
5. Microsoft Head Office, Epping, Sydney

PERFORMANCE CHARACTERISTICS

- Permanently seals existing cracks up to 2.00mm.
- Reseals future hairline cracking.
- Reduction of chloride diffusion coefficient by 89% to 3.5 (10^{-12} m^2/s).
- Water permeability reduced by 70% to 5.0 (10^{-12} m/s) at 10kg/cm^2.
- Increases surface hardness from 6 to 8 on Moh's scale.
- Reduces scaling in freeze-thaw environments by 89% at 50 cycles.
- Allows 84.1% moisture vapour permeability.
- Suitable for tanking applications (positive hydrostatic pressure) - tested to 400 metres.
- Non Toxic - Certified suitability for potable water.

SPECIFICATION DETAILS

MATERIAL SPECIFICATION

"The waterproofing solution shall create a vapour permeable sub-surface barrier to prevent water leakage and ingress of contaminants into the cracks and concrete matrix."

"The solution will be a non-toxic, clear, odourless silicate based material with proprietary biochemical modification such as ***Radcon Formula #7®*** *manufactured by Radcrete Pacific Pty. Ltd."*

"The solution will penetrate into concrete and react with free calcium and water at ambient temperatures. The solution will form a non-water soluble calcium silicate hydrate gel complex which is a chemically resistant compound in cracks, pores and capilliaries."

"The product will seal existing leaking cracks up to 2.00mm. In the matrix, it remains reactive with water to provide autogenous healing properties to future hairline cracks."

CONCRETE MIX DESIGN

Radcon #7 will meet or exceed its stated performance when applied to slag blend concrete and ordinary Portland cement type GP concrete; Type "C" fly-ash replacement up to 30% of cement replacement. Type "F" fly-ash is NOT suitable for use with Radcon # 7 due to causing pozzolanic reactions in the concrete.

LARGE OR STUBBORN CRACKS

Grind out and flood crack with product. A Calcium solution may be required to bulk up the product in large cracks. Fill with a non-shrink or polymer modified mortar; or revert to an elastomeric sealant if there is a possibility that the crack is "working" or "volatile". In large cracks where the product runs through quickly, temporarily use waterproof tape on the underside to pond product in the crack.

CURING COMPOUNDS

Water curing is preferred - minimum 7 days. PVA (Polyvinyl acetate) which bio-degrades within 28 days is also suitable. Other materials such as chloro-rubber, resins, wax emulsions and acrylics are suitable but will have to be removed by grit blasting or chemical wash to allow proper penetration of the product.

LIMITATIONS

Radcon Formula #7® is not suitable for sealing working/volatile cracks as a result of structural defects or caused by mechanical damage. (see LARGE OR STUBBORN CRACKS)

The product is not suitable for sealing where segregation and voids are likely such as construction/pour joints. Nor suitable around penetrations where there is a non-masonry/cementitious interface. (See ANCILLARY DETAILING RECOMMENDATIONS)

Radcon Formula #7® is not suitable for negative hydrostatic pressure applications such as the inside face of a basement/retaining wall which is constantly wet.

APPLICATION SPECIFICATION

Basic Application Requirements

- **Radcon Formula #7®** must be applied to a clean, dry, dust-free concrete surface, at least 28 days old. Renders may be treated after 7 days.
- Any materials that retard penetration such as curing compounds must be removed prior to application.
- Where segregation or voids are apparent, chip out, spray with **Radcon Formula #7®**, then make good with cementitious materials.
- Good concrete practice should be followed such as adequate curing, compaction and vibration.
- Old or carbonated concrete requires Calcium treatment to reinstate free Calcium. Contact Radcrete Pacific Pty. Ltd.
- Do not apply where ambient temperatures are below +5°C or above +35°C.

Application Rates

Normal:	1 litre to 5 square metres.
Smooth, dense surfaces:	up to 1 litre to 6 square metres.
Rough, porous surfaces:	down to 1 litre to 4 square metres.
For cracked areas:	an additional 1 litre per 5 lineal metres is recommended.

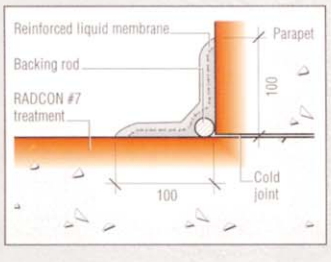
Application Method

1. Locate all cracks and spray with solution ensuring they are flooded with product.
2. Apply the solution to the remaining area at a rate of between 4-6 sq.m. per litre.
3. When surface becomes touch dry - (usually 2-6 hours depending on wind conditions and ambient temperature) flood spray the treated areas with water.
4. On Day 2 - 24 hours later water again.
5. On Day 3 - 24 hours later water again.
6. It is advisable that after the third watering, pond the area for a minimum of 12 hours to verify a waterproof seal has been achieved.

ANCILLARY DETAILING RECOMMENDATIONS

For faster and more effective waterproofing with **Radcon Formula #7®** it is important to take into consideration specific design detailing. These detailing features allow the designer/builder to optimise the inherent benefits of **Radcon Formula #7®** giving the concrete structure greater durability against the ingress of water and contaminants.

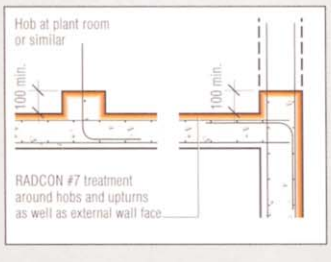
COLD JOINTS



Where parapet walls sit directly onto a concrete slab a cold joint is formed. Possible voids or shrinkage cracks can occur. To waterproof this joint effectively whilst allowing for lateral movement, we recommend the use of a two coat reinforced liquid membrane strip extending 100mm either side of the joint as detailed here.

If upturns are incorporated into the concrete pour then these strip seals are not required saving time and money.

UPTURNS/HOBBS



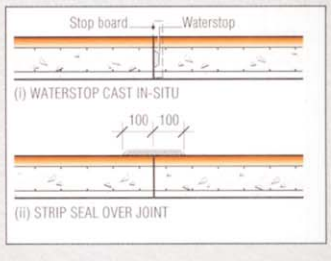
An upturn is a raised section of concrete approximately 100mm which is formed as part of the base slab. These in-situ upturns are encouraged where parapet walls or expansion joints are planned to raise the cold joint above the floor level.

Fall lines should be incorporated into the slab pour for drainage and elimination of toppings or screeds.

CONSTRUCTION/POUR JOINTS

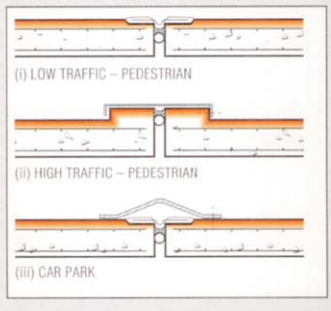
At these joints, we recommend the use of: (i) a waterstop material such as a reputable swelling hydrophilic rubber or bentonite clay to alleviate the risk of leakage through potential honeycombing. If the slab has already been poured, (ii) a reinforced liquid membrane extending 100mm either side of the joint is recommended.

Construction joints should be formed vertically with a 'stop board' to ensure good compaction and compressive strength on either side of the joint.



EXPANSIONS JOINTS

Three expansion joint systems are detailed here: (i) for low pedestrian trafficable rooftops involving an adhered membrane strip and elastomeric sealant, (ii) for high pedestrian traffic rooftops involving the use of upturns, metal plating and elastomeric sealant, and (iii) car park environment using system (i) plus a metal speed hump. All systems involve a dual approach so that if one material fails then the secondary seal will remain in place.



PENETRATIONS

Where pipes form penetrations through the structural concrete these should be detailed in one of two ways: either, (i) use a waterstop material cast in-situ or (ii) use a reinforced liquid membrane strip 100mm around the penetration.

For more detailed drawings of these design considerations please refer to the Datasheet or our technical web page www.radcrete.com.au.

INDEPENDENT TECHNICAL APPRAISALS & REPORTS

The following list of technical appraisals and reports address the unique performance capabilities of **Radcon Formula #7®**. This list is by no means exhaustive, Radcrete Pacific Pty. Ltd. hold many tests from a variety of institutes around the globe for just as many specific applications.

When comparing **Radcon Formula #7®** with other materials one must appreciate the mechanism by which the product achieves a seal. That is, the treated concrete will still absorb water into the top surface to reactivate the product and create a waterproof barrier. Naturally this mechanism does not lend itself to tests such as absorption.

The correct way to evaluate the product is by the reduction of the water permeability coefficient of the treated concrete. **Radcon Formula #7®** creates a watertight structure by sealing cracks up to 2.00mm and significantly reducing the permeability of the matrix.

As commitment to the ongoing research and development of the product, new testing methodologies are constantly being explored in many different regions of the world. For a comprehensive overview of these test reports detailed here, please contact your nearest representative.

ABSAC Technical Opinion No.193
Building Research Centre (UNSW)
- Condition Survey

Building Research Centre (UNSW)
- Laboratory Evaluation
- ISAT to B.S. 1881
- Water Permeability
- Chloride Ion Diffusion (Taywoods)

Building Research Centre (UNSW)
- Corrosion Behaviour in Cracks - Marine Environment

University of Bologna, Italy
- Crack Widening & Sealing

Concrete Institute of Australia
- Watertight Concrete - Current Practice Note 28

US Highway Dept (USA)
- Bridge Deck Surface Treatments
- Adhesion of Asphalt to treated surface
- Resistance to Water Absorption
- Freeze-Thaw Scaling Resistance
- Effect of Hot (160°C) Asphalt on treatment
- Effect of Out-gassing on material
- Outdoor test

Warnock Hersey Professional Services (Canada)
- Depth of Penetration
- Water Absorption
- Vapour Permeability
- Chloride Ion Penetration
- Freeze-Thaw with De-icing Salts
- Chemical Resistance
- Slip Resistance
- Viscosity
- Non-Volatile Contents
- Relative Density
- pH Value
- Hardness Test

SINTEF (Norway)
- Permeability under 10&40m head of pressure
- Chloride Ion Diffusion - wetting/drying

SISIR (Singapore)
- Non-Toxicity
- Potable Water Certification

University of Sydney
- Calcium Leaching

MATERIAL SAFETY DATA SHEET INFORMATION

Following is an extract from the **Radcon Formula #7®** Material Safety Data Sheet covering the product's general properties.

HEALTH NOTES

Swallowed - No known ill effects.
Eye Exposure - Severe irritation. Flush with large amounts of water.
Skin - No known ill effects have been noted however, with chemicals, one should always avoid contact with skin.
Inhaled - No known damage to internal tissue.

IDENTIFICATION CODES

Australian Adchem Code - Material 15660
USA Manufacturers Code C - 101

PRODUCT PROPERTIES

Colourless, clear to slightly opaque, odourless, soapy feel.
Non-toxic & biodegradable
Percent non-volatile solids: 27.7%
Specific gravity at 25°C: 1.225
0.0% VOG (Volatile Out-Gassing)
Flash point - no true flash - boils at 101°C
Auto ignition temperature - N/A Non-explosive
Viscosity - 14.3 centipoise or 0.1172 Stokes
Hazardous chemicals - Sodium Silicate (modified)
pH 11.7
Elements: Na, Si, Fe, Ni, Cu, Zn, Zr
modified Sodium Silicate (major constituent)

PRECAUTIONS FOR USE

Exposure Limit - No known limit. Avoid skin & eye contact as a general precaution.

Ventilation - Exhausting required in totally enclosed environments. Breathing apparatus advised in these locations.

Personal Protection - Avoid direct contact with eyes at all times. Protective goggles should be worn.

Flammability - Non-flammable.

Storage and Transport - To be stored or decantored into lined steel drums or polypropylene containers.

APPLICATION EQUIPMENT

Radcon Formula #7® has a similar viscosity to water thereby enabling easy application. Depending on the type of application that is being undertaken different equipment can be used.

The application equipment ranges from hand sprayers for small/detailed work, to motorised spray units for car parks, bridge decks or airport runways.

HAND SPRAYER

This hand sprayer is commonly available in hardwares. It is ideal when addressing spalling cavity treatment or jobs of a few square metres.

BACK PACK SPRAY UNIT

Utilising a Solo® ~ 30psi pressurised knapsack spray, one can expect a coverage or 100 to 150 square metres per hour. This makes the unit ideal for small podium decks and balconies.

MOTORISED SPRAY UNITS

On large sites, a motorised sprayer will usually produce a coverage of 600 to 800 square metres per hour.

Equipment should be used on the lowest pressure setting (30 psi) as atomising the product will increase waste if there is any wind. The units normally comprise of a 1.5hp pump with adequate hosing for easy access on site.

APPLICATION PRECAUTIONS

Ensure all glass, aluminium, wood stains and painted metal railings are protected from **Radcon Formula #7®** over-spray or any residual product during watering procedures. For cleaning all equipment should be thoroughly flushed with water.

Work should not be undertaken utilising **Radcon Formula #7®** without first consulting Radcrete Pacific Pty. Ltd. or referring to the Datasheet or our technical web page www.radcrete.com.au for specific detailing.

PACKAGING - TECHNICAL SERVICES - GUARANTEES

Radcon Formula #7® is available in 2ltr, 5ltr, 20ltr and 200ltr drums. Product is manufactured in full. No product dilution.

SHELF LIFE & STORAGE

No known limit to shelf life.
Keep container sealed and avoid prolonged exposure to direct sunlight. Always agitate drum or container before use.

TECHNICAL SERVICES

Complete technical information including testing data and detailing is available from Radcrete Pacific Pty. Ltd. and authorised distributors. Other published information includes the Datasheet and Design Detailing www.radcrete.com.au. For your nearest technical representative, please contact Radcrete Pacific Pty. Ltd.

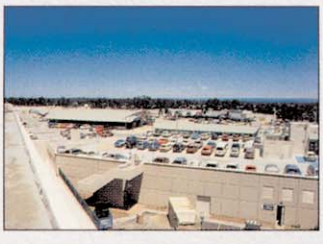
GUARANTEES

10 or 15 year guarantees for **Radcon Formula #7®** treated areas are available where Approved Applicators are used and in suitable applications. Contact the manufacturer for further information and confirmation of suitability.

1. Car Parks

Radcon #7 is ideal for this application as it forms a sub-surface waterproof barrier and seals cracks, even when exposed to high thermal stresses. Combine this with Radcon #7's increase in surface hardness, no loss in slip resistance and easy cleaning due to limited penetration of oil and the choice becomes clear.

The product is applied directly onto the structural concrete without any protection required. Thus if there is any leakage in the future, repairs can be made immediately to the structural concrete, without any tracking problems.



Westfield Market Town, Mt. Druitt, NSW, Australia.
8,700 sqm. Radcon #7 treated to entire car park/rooftop directly over retail area.

Seacon Square Shopping Centre, Bangkok, Thailand.
50,000 sqm. Radcon #7 applied to entire car park/rooftop directly over retail area.

2. Rooftops/Podium Decks

The main benefits of Radcon #7 are long term waperproofing performance in high thermal stress sites, combined with major cost reductions, low maintenance and absolute UV resistance. The finished treatment leaves the structural concrete completely trafficable to generate more useful space for a building.

Alternatively, the roof may be covered with outdoor synthetic grass or tiles with no bond loss to the substrate.

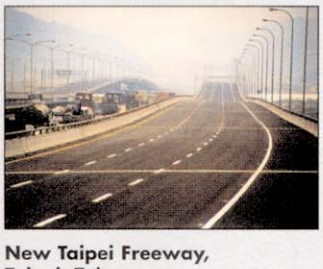
Lippo Karawaci Shopping Centre, Jakarta, Indonesia.
50,000 sqm. Radcon #7 used solely to waterproof this flat concrete roof directly over retail.

Australian Taxation Office, Wollongong, Australia.
3,500 sqm. Radcon #7 used to waterproof the concrete roof and podium level.

3. Bridge Decks/Raised Freeways

The multiple benefits of Radcon #7, specifically, fast application, complete trafficability, concrete protection and reduced maintenance costs, make this treatment a most cost effective protection for civil structures. Another major benefit is the adhesion of asphaltic topping to the substrate is not impaired.

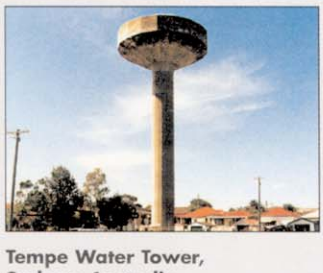
Perth Bridge, Tasmania, Australia.
2,600 sqm. Radcon #7 applied directly onto exposed structural concrete that was eroding from traffic & freeze/thaw damage.



New Taipei Freeway, Taipei, Taiwan.
65,000 sqm. Radcon #7 used to waterproof 4km of raised freeway prior to asphalt topping.

4. Water Holding Vessels

The non-toxic nature of Radcon #7 and ability to withstand severe hydrostatic pressure makes this application ideal for potable water for human consumption, aquariums and water treatment plants.



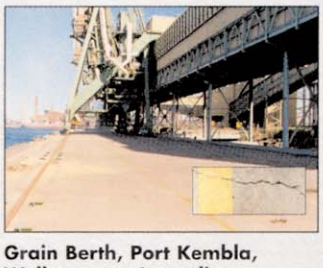
Tempe Water Tower, Sydney, Australia.
1,000 sqm. Radcon #7 used to waterproof the inside of this leaking water tower.

Ramada Resort, North Ryde, Australia.
2,000 sqm. Radcon #7 used to waterproof this lake completely suspended over a car-park.

5. Concrete Protection

By sealing both the matrix and cracks up to 2.00mm, Radcon #7 provides high resistance to chloride ions from salt water or de-icing salts. In cracks, the product provides a highly alkaline environment to maintain passivity to the reinforcement, and dramatically reduces spalling & mass loss in freeze-thaw environments.

Sandringham Yacht Club, Victoria, Australia.
3,000 sqm. Radcon #7 applied to this pre-cast wave barrier for concrete protection.

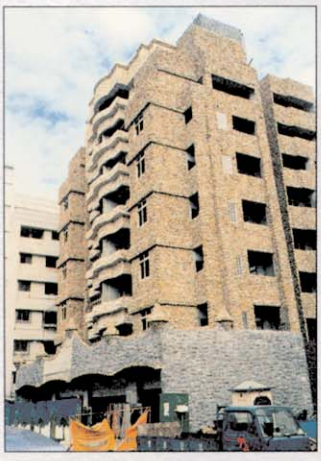


Grain Berth, Port Kembla, Wollongong, Australia.
Radcon #7 alone, was used to seal these leaking cracks up to 2.00mm.

6. Facades

Facades either cast in-situ or rendered will benefit from a Radcon #7 treatment by: sealing shrinkage cracks, stopping efflorescence and reducing permeability. Paints and other coatings may be applied over the treatment with no bond loss. De-laminating render may be re-bonded by Radcon #7 injection.

Heritage Building, Melbourne, Australia.
This single skinned rendered building had leaked through the facade for many years. After several coats of paint were removed Radcon #7 was applied to stop all leakage.



Vanco Building, Taipei, Taiwan.
3,000 sqm. Radcon #7 was applied to the complete facade to prevent efflorescence & water penetration.

7. Tiled Areas/ Shower Recesses

In remedial applications, Radcon #7 is applied to the tiled surface to prevent the penetration of water through porous mortar joints. Mortar joints should be in good condition and any cracks in the tile bed should be treated with caution as they may be volatile. Therefore, they may require grind and filling with an elastomeric sealant material to allow for movement.

In new construction, Radcon #7 is also suitable for application beneath a tile bed and will in fact increase the bond strength between the mortar bed and the structural concrete by 27%.

Monument Yogya, Indonesia.
Radcon #7 was applied to 5,000 sqm beneath the tiled finish.

Detail of shower recess.
Radcon #7 can be applied to mortar joints around tiles to stop water leakage.

The site applications, briefly outlined herein, show just some of the major Radcon #7 uses for waterproofing and durability improvement of concrete. Comprehensive information is detailed in the Datasheet or our web page www.radrete.com.au.

Appendix F: Degusa Degadeck Crack Sealer

degussa.
Specialty Acrylics

Date: October 2003

Instruction Guide

DEGADECK® Crack Sealer

Methacrylate reactive resin for sealing cracks and concrete slabs

DEGADECK Crack Sealer is a very low viscosity, low surface tension, rapid curing methacrylate reactive resin used to fill and seal cracks in concrete structures. DEGADECK Crack Sealer also protects sound concrete against water and chloride ion ingress.

Cracks ranging from hairline width to 1/8" (3 mm) are easily penetrated by a flood application of DEGADECK Crack Sealer over properly prepared deck surfaces. Cure times of 35 - 45 minutes can be maintained at temperatures ranging from 14° F to 104° F (-10° C to 40° C).

DEGADECK Crack Sealer is

- fast-curing for rapid restoration of traffic
- simple to use
- solvent-free
- weather- and aging-resistant
- compatible with methacrylate coatings and wearing course materials
- shelf-life stable

DEGADECK Crack Sealer is NOT

- a high molecular weight methacrylate (HMWM)
- tacky or oily after curing
- a vertical surface treatment
- a decorative coating system
- a traffic deck or wearing course system

How to Use DEGADECK Crack Sealer

Step 1 – Evaluate
Inspect the concrete substrate before preparation. Note the location of surface cracks and the presence of dust, dirt, oil, laitance, curing compounds and other contaminants. Inspect the underside of the deck for signs of leakage due to full depth cracks. Check weather forecast to ensure dry conditions. Wet substrates must be allowed to dry prior to beginning work.

Step 2 – Prepare the Substrate
Using a dust-free, mobile shotblaster, brush-blast the substrate to expose surface cracking. Do not use wet preparation methods.

Step 3 – Evaluate the Prepared Substrate
Perform a second inspection, noting newly-found surface cracks. Mark these for pre-treatment. Clean out cracks and the deck surface with oil-free compressed air.

Step 4 – Mix the Components
Using clean, dry plastic buckets and scoops, add Powder Hardener to Crack Sealer and mix until dissolved (approximately 1 minute). A drill-mounted paddle mixer should be used for larger batches. Mixed DEGADECK Crack Sealer must be used immediately. Do not exceed 5-gallon (20 l) batch mixes.

Powder Hardener Dosing*
Basis: 1 gallon DEGADECK Crack Sealer

Temp in °F (°C)	Weight %	Vol. Oz.	Packets
41 (5)	5	10.5	5
50 (10)	4	8.5	4
59 (15)	3	6.5	3
68 (20)	2	4	2
86 (30)	1	2	1

*Please consult Degussa for applications outside of this temperature range.

Step 5 – Pre-treat Wide Cracks
Cracks up to 1/8" (3 mm) should be treated individually prior to deck application. Full depth cracks may require alternative treatment to prevent runoff of resin. Fill wider cracks with dry, 30 mesh silica sand. Mix a small amount of Crack Sealer, pour into cracks and distribute with a paint brush. Squeeze bottles can also be used.

Step 6 – Apply to Deck
Immediately pour batches of mixed Crack Sealer onto the substrate. Do not allow the mixed batch to remain in the mixing vessel. Distribute with ½" to ¾" (13 - 20 mm) nap solvent grade paint rollers, working the material into cracks. Do not allow material to pond. Application rate is 100 ft^2/gal (2.5 m^2/l). Working time for DEGADECK Crack Sealer is between 10 to 15 minutes after Powder Hardener addition.

Step 7 – Broadcast Sand
Randomly broadcast a 30 mesh (600 μm), dry aggregate into the wet, uncured resin at the maximum rate of 4 lb/100 ft^2 (200 g/m^2).

Step 8 – Allow to Cure; Open to Traffic
Allow one hour for Crack Sealer to gain full mechanical properties. Check for dry-to-touch condition. End result should be a darker-colored, matte finish with a minimal surface film and some loose broadcast aggregate. Open to traffic. Although the surface film is sacrificial, cracks will continue to be protected.

Step 9 – Cleanup
Clean tools as needed with acetone, ethyl acetate or similar solvents. Collect and dispose of all site wastes.

Safety

DEGADECK Crack Sealer is a flammable liquid in the uncured state. Read and understand product labels and Material Safety Data Sheets of all components prior to use.

Technical Support

Application and engineering services in the NAFTA countries are available from Degussa. Services may include step-by-step problem solving in such areas as project assessment, material selection and development of specifications. For more information, please contact Degussa by phone at 800-477-4545, by fax at 732-981-5108 or by e-mail at srs-information@degussa.com

degussa.
Specialty Acrylics

Date: April 2003
Supersedes: August 2002

Product Data Sheet

DEGADECK™ Crack Sealer

Methacrylate reactive resin for sealing cracks and concrete slabs

Product Profile

DEGADECK Crack Sealer is a very low viscosity, low surface tension, rapid curing methacrylate reactive resin used to repair and seal cracks in concrete structures. Cracks ranging from hairline width to 1/8" (3 mm) are easily penetrated. DEGADECK Crack Sealer also protects sound concrete against water and chloride ion ingress. DEGADECK Crack Sealer is mixed with a dibenzoyl peroxide hardener and applied at 100 ft^2/gal (2.5 m^2/l) over properly prepared concrete surfaces. Cure times of 35 - 45 minutes can be maintained at temperatures ranging from 14° F to 104° F (-10° C to 40° C). The cured resin creates a barrier that prevents water and water-borne contaminants from entering the substrate and preventing premature deterioration. In comparison with conventional sealers, DEGADECK Crack Sealer is solvent-free, fast-curing, enabling rapid turnaround, weather- and aging-resistant and compatible with methacrylate coatings and wearing course materials.

Uses

DEGADECK Crack Sealer is recommended for bridge decks, parking structures and related civil engineering applications. The use of DEGADECK Crack Sealer can be combined with other methacrylate coating materials to provide a complete systems approach to concrete protection.

Application

DEGADECK Crack Sealer is applied in a gravity-fed process by roller.

DEGADECK Crack Sealer must be mixed with the appropriate amount of Powder Hardener just prior to application. Air/substrate temperature determines the amount as follows:

Basis: 1 gallon DEGADECK Crack Sealer

Temp in °F (°C)	Weight %	Vol. Oz.
40 (4)	5	11.0
50 (10)	4	8.5
60 (16)	3	6.5
70 (22)	2	4.5

Powder Hardener is added to the resin and mixed until dissolved (approximately 1 minute). Mixed DEGADECK Crack Sealer must be used immediately. It is recommended not to exceed 5-gallon (20 l) batch mixes. The contents of the mixed batch should be immediately poured on to the substrate and distributed with ½" to ¾" (13 - 20 mm) nap solvent grade paint rollers. Do not allow the mixed batch to remain in the mixing vessel. It is advisable to randomly broadcast a 30 mesh (600 μm), dry aggregate into the wet, uncured resin at the rate of approximately 4 lb/100 ft^2 (200g/m^2).

Working time for DEGADECK Crack Sealer is between 10 to 15 minutes once it has been applied to the substrate. Full cure to specification will be between 45 minutes to 1 hour. All other application procedures are covered in the DEGADECK standard specification documents.

Characteristics

	Units	Value
Appearance		Liquid
Specific gravity (DIN 51757)		0.97
Viscosity at 73 F (23 C) (ASTM D2393)	cP mPa-sec	5-15
Flash point (DIN 51755)	° F ° C	48 9

Typical Performance Properties

	Units	Value
Tensile strength (ASTM D638)	psi MPa	4,500 31.0
Elongation at Break (ASTM D638)	%	5.5
Shore hardness (ASTM D2240)	D	> 80
Water absorption (ASTM D570)	%/24h	0.60

Packaging & Shipping

DEGADECK Crack Sealer is sold by weight and packaged in 38 lb. (17.3 kg) and 396 lb. (180 kg) non-returnable steel drums. This is equivalent to 4.7 gal (17.8 l) and 49.0 gal (185.5 l), respectively. It is classified under DOT regulations as Resin Solution, UN 1866, Class 3, PG II.

Storage

Keep cool, dry and out of direct sunlight. Maximum storage temperature is 68° F (20° C). Minimum shelf life under these conditions is six months from date of delivery.

Safety

DEGADECK Crack Sealer is a flammable liquid in the uncured state. Read and understand product labels and Material Safety Data Sheets prior to use.

Technical Support

Application and engineering services in the NAFTA countries are available from Degussa Corporation. Services may include step-by-step problem solving in such areas as project assessment, material selection and development of job procedures. For more information, please contact Degussa by phone at 800-477-4545, by fax at 732-981-5108 or on the web at www.degussa.com

Warranty

DEGADECK resins are manufactured to ISO 9001 standards. Information available upon request.

Complimentary Products

DEGADECK Bridge Overlay, DEGADECK Polymer Concrete

Appendix G: Tamms Dural 335 Literature

TECHNICAL DATA SHEET

DURAL® 335

Ultra Low Viscosity, Penetrating Epoxy Crack Healer-Sealer

1. **DESCRIPTION:** DURAL 335 is a solvent free, two component, moisture insensitive, ultra low viscosity epoxy sealer.

FEATURES AND BENEFITS

- ***Penetrating epoxy crack healer-sealer***
- ***Alternative to hazardous methylmethacrylates***
- ***Solvent free, no odor***
- ***Ultra low viscosity***
- ***High Strength***
- ***Moisture Insensitive***
- ***Protects treated surface from salts, chemicals, and water absorption***

APPLICATIONS

Used interior and exterior to seal slabs, gravity feed resin into cracks and pressure inject cracks on:

- ***Bridge decks***
- ***Parking garage decks and ramps***
- ***Airport runways***
- ***Roadways***

MATERIAL PROPERTIES
75°F AND 50% RH

Mixing Ratio (A : B) by volume	4:1
Mixed Viscosity, cps	80-100
Gel Time (100 gms), mins.	40-50
Pot life (1.25 gal unit), mins.	20-25
Tensile Strength, ASTM D638, psi	7,000-8,000
Tensile Modulus, psi	300,000
Tensile Elongation, %, ASTM D638	1-5
Compressive Strength, psi, mortar ASTM C109 (3 parts sand)	8,000-9,000
Slant Shear Bond Strength, psi ASTM C882	1,800-2,000
Flexural Strength, psi, ASTM D790	9,000-10,500

Values presented are typical laboratory data

2. **SURFACE PREPARATION:** Surface must be structurally sound, clean, dry and free of laitance, dust, dirt, oil, coatings, form release agents and other contaminants. Remove contamination by sandblasting or shotblasting. Remove defective concrete, honeycomb, cavities, joint cracks and voids by routing to sound material. Rebuild areas with suitable patching materials. Smooth, precast and formed concrete surfaces must be cleaned, roughened and made absorptive by sandblasting or shotblasting. Blow debris and residue out of cracks and from the surface with a moisture-free and oil-free air jet. Mask expansion joint sealants to prevent adhesion of DURAL 335 to the joint surface. Surfaces and cracks must be completely dry before DURAL 335 application to obtain maximum penetration. For further information contact Tamms Technical Service Centers.

3. **MIXING INSTRUCTIONS:** Premix Part A and Part B. Combine 4 parts by volume of Part A (Base) to 1 part by volume of Part B (Hardener) in a clean container, and mix thoroughly with a slow speed motor and "Jiffy" Mixer. Scrape the bottom and side of the mixing container at least once. Do not aerate mixture.

4. **APPLICATION TECHNIQUES: For sealing slabs:** Pour the mixed DURAL 335 onto the prepared surface in a wave form and distribute evenly with a short nap roller or squeegee to fill voids, cracks and porous areas. Before the resin becomes tacky, use a squeegee on a smooth surface and a broom on textured surfaces to remove any excess resin that has not penetrated the surface. To improve skid resistance of the surface or where subsequent topping or coating application is desired, broadcast 0.2-0.8 lbs/sq.yd. of silica sand not earlier than two hours (at 75°F) after application of DURAL 335 but before the DURAL 335 begins to become tack free. Ensure that the coating or toppings are applied within the recoat window of the application conditions. **Grouting cracks:** Gravity feed – Pour neat mixed DURAL 335 into vee-notched cracks until completely filled. **Pressure injection** – Set appropriate injection ports depending on the system used. Seal around port and surface of crack using Dural Fast Set Epoxy Gel. Inject neat resin using automated (2 part Injection unit) or manual methods (caulking gun). Maintain slow steady pressure until the crack is filled with the injection resin. For complete details, consult Tamms Guide Specifications on "Epoxy Pressure Injection of Structural Concrete".

5. **COVERAGE: For slab sealing:** 100-200 sq. ft./gal. for typical concrete surfaces. **For crack grouting:** Coverage depends on extent and depth of cracking.

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6. **CLEAN UP INSTRUCTIONS:** Clean tools and equipment immediately following use with methyl ethyl ketone or xylene. Clean spills or drips while still wet with the same solvent. Dried DURAL 335 will require mechanical abrasion for removal.

7. **PACKAGING & STORAGE:** DURAL 335 is available in 1.25 gallon and 5 gallon units.
   Storage: 50° and 90°F. Do not store below 50°F.
   Shelf Life: One year in original container, properly sealed. Return of improperly stored materials will not be accepted.

8. **CAUTIONS:** Apply DURAL 335 when surface and ambient temperatures are between 50-90°F. In some cases, on highly porous surfaces, a second coat may be required. If a second coat is required please contact Tamms Technical Service for a recommendation. Multiple applications of DURAL 335 at 75°F must be within 24 hours of the preceding application. Excess DURAL 335 left on the concrete surface will reduce skid resistance. Apply a test area to confirm suitability. DURAL 335 is not intended for sealing cracks under hydrostatic pressure. Do not store DURAL 335 below 50°F. Allow new concrete to cure 28 days before DURAL 335 application.

9. **ENVIRONMENTAL AND SAFETY:**
   Industrial Use Only.
   Component "A": Contains epoxy resin. Vapors can cause respiratory irritation. Skin and eye irritant. Can cause sensitization after prolonged or repeated exposure. Use of safety goggles and chemical resistant gloves. Use only with adequate ventilation.
   Component "B": Is **CORROSIVE.** Contains amines. Contact with eyes and skin may cause severe burns. Can cause sensitization after prolonged or repeated use. Use of safety goggles and chemical resistant gloves is highly recommended. Use only with adequate ventilation.
   First Aid: In case of skin contact, wash immediately and thoroughly with soap and water. For eye contact, flush immediately with plenty of water for 15 minutes. Consult a physician immediately. For respiratory problems, remove person immediately to fresh air.
   Disposal: Collect with absorbent material. Dispose of in accordance with current local, state and federal regulations.
   READ MATERIAL SAFETY DATA SHEET BEFORE USING. FOR INDUSTRIAL USE ONLY. **KEEP AWAY FROM CHILDREN AND ANIMALS.** EMERGENCY RESPONSE PHONE NUMBERS ARE (800) 424-9300 (CHEMTREC) OR (800) 862-2667 (TAMMS).

10. **TECHNICAL SERVICE:** For application procedures or surface conditions not specified above, please contact:

TAMMS INDUSTRIES, INC.
3835 State Route 72, Kirkland, IL 60146
800-862-2667
Fax: 815-522-2323
www.tamms.com

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