FIELD PERFORMANCE OF EXPERIMENTAL BRIDGE DECK MEMBRANE SYSTEMS IN VERMONT

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Field Performance of Experimental
Bridge Deck Membrane Systems
in Vermont

BY

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Introduction

Vermont's membrane evaluation program began in 1971 with the application of two experimental systems on four new bridge decks. From that point to the present, a total of 33 different systems have been field applied on 69 new Portland Cement Concrete bridge decks. The products have included 15 preformed systems; 7 epoxies, 5 hot applied materials, 4 polyurethanes, and 2 tar emulsion systems. Because the membrane systems were considered experimental, the applications were closely monitored and reported under the National Experimental and Evaluation Program #12, Bridge Deck Protective Systems. The information included background data on deck construction, concrete test results, condition of the decks, membrane product data, laboratory test results, observations made during the membrane applications, cost information, preliminary field test results and discussions on the applications. Summaries of each membrane system were concluded with recommendations on further use.

Field Evaluation Procedure

Follow-up field evaluations of the membrane systems began in 1975 on products which were exposed to a minimum of two winters of deicing chemical applications. The investigation that year included 22 bridges which had been waterproofed with 14 different membrane systems. Field testing in 1976, 1977 and 1978 included 37, 34, and 47 structures respectively. Through the present date, field performance results have been obtained on 27 of the 33 experimental systems in place.

Field testing the first two years included electrical resistivity readings, electrical half cell potential readings, and the recovery of concrete samples for the determination of chloride content by wet chemical analysis. Comparisons were made between the resistivity readings and the chloride levels detected at specific resistivity test locations. When correlation between the two test methods was found to be less than 60 per cent, resistivity testing was deleted from the evaluation program in the following years.

Steel potential readings obtained at the same grid points as the resistivity tests were all below the 0-.35 volt level considered to be the corrosion threshold. Such readings were in agreement with the core results which indicated chloride levels were insufficient to cause corrosion of the reinforcing steel.

For the past two years (1977-1978), the performance of the various membrane systems has been considered only in relation to the presence or absence of chloride above base levels as determined by chemical analysis of recovered concrete samples. Such samples were taken at points 1, 5 & 15 feet off the curb line. The 1 foot offset was selected because of the potential for leakage at the critical curb line area while the 15' offset establishes membrane performance in the wheel path area which is subject to aggregate puncture under continuous traffic. The 5 foot offset is located in the breakdown lane where satisfactory performance would be expected if the membrane was not damaged during paving or laterial leakage did not occur. In most cases the test areas were located on the low end of the decks where chloride concentrations would be heaviest. Where superelevations resulted in drainage away from the breakdown lane, concrete samples for chemical analysis were obtained from the opposite curb line. The pulverized concrete samples were procured from 0-1 inch and 1-2 inch depths with the aid of a rotary hammer and 3/4 inch carbide tipped twist drill. The overlying bituminous pavement was removed by the same procedure followed by cleaning with a blow out bulb.

A depth gauge attached to the drill was used to obtain the proper depth. A metal template was used to catch the pulverized sample brough up by the bit. Material remaining in the core hole was removed with a scoopula and blow out bulb. Core holes were patched with a quick-set cement.

A wet chemical analysis was used to determine the total chloride content in the recovered concrete samples. The basic procedure consisted of freeing chloride iron with nitric acid, adding silver nitrate solution, filtering, and titrating with a solution of ammonium thiocyanate.

Membrane Performance

At the present time, field test results have been obtained on 46 of the 69 experimental bridges which were subjected to an average of 3.7 winters of deicing chemical applications in which chloride applications averaged over 30 tons per two lane mile per year. The test results over the past four years which include 27 of the 33 products in use reveal that chloride contamination has occurred in the top inch of concrete at 38 per cent of all locations tested (see summaries on pages 9 and 10). The amount of chloride above the base level averaged 88 ppm or 0.35 pounds of chloride per cubic yard of concrete in the top inch of the contaminated samples. Seven percent of the 359 test locations exhibited chloride levels over one-half pound in the top inch of concrete with the highest reading recorded at 1.8 pounds. Contamination in the second inch of concrete was found on 19 percent of the cores with chloride levals averaging 70 ppm above base levels or 0.28 pounds per cubic yard of concrete. Chloride levels slightly over one-half pound were recorded on 2 percent of the samples. The difficulty of obtaining a satisfactory seal along the curb lines was evidenced by the detection of contamination in 54 percent of the cores taken at the one foot offset. Such cores made up 47 percent of all the contaminated samples while 28 percent were located at the 5 foot offset and the remaining 25 percent were at the 15 foot offset.

When the effectiveness of the various membranes are considered by general type, the best performance to date has been provided by the hot applied materials which have been exposed to an average of 4.7 winters of deicing salt applications. Contamination has been limited to 24 percent of the samples taken from the top inch of concrete with an average of less than 1/4 pound of chloride found in the contaminated cores. The test results to date show that Uniroyal 6125 and NEA 4000 are two of the more promising hot applied materials available for use. It should be noted that neither product is recommended for superelevated structures or on grades in excess of 3 percent due to the potential for stability problems with the bituminous overlays.

The standard preformed membranes (H.D. Bituthene, Protecto Wrap M400, Royston No. 10) were nearly as effective as the thermoplastic or thermosetting materials following an average exposure of 3.4 winters. Contamination was limited to 24 percent of the samples from the 0-1 inch depth and 8 percent from the second inch with less than 1/3 pound of chloride found in the average contaminated sample. Fifty percent of the contamination was found along the curb lines where it is hoped that more recent installations will be more effective since the specification now requires the use of compatible liquid polyurethane sealants along the membrane perimeter and vertical curb face. Poor performance has been obtained with all three products after five winters exposure. Further testing will be required to determine if such results occurred due to specific conditions or if they are an accurate indicator of the effective life of the three products.

The five vulcanized, cured or cross-linked preformed elastomer systems selected as the most promising membrane materials under Phase I of the NCHRP Project 12-11 have prevented chloride intrusion on 67 percent of the cores after an average of three winters exposure. Leakage detected on three of the five systems may have been due in part to blisters which occurred during and after the installation of the first one inch course of pavement.

Four polyurethane systems have prevented chloride intrusion on 59 percent of the samples taken after an average of 3.4 winters. At the present time, Duralseal 3100, a 100 percent solids material appears to be the most promising with no leakage detected through four winters exposure.

Epoxy and tar emulsion systems prevented intrusion on 47 and 45 percent of the samples respectively. Chloride levels averaged 1/3 pound with the epoxy products after an average of 3.2 winters. The structures treated with tar emulsion revealed an average of 0.45 pounds chloride in contaminated samples following an average of 4.6 years.

Summary

Vermont's experimental membrane evaluation program currently includes 33 different systems which have been field applied on 69 new bridge decks. Field performance results have been obtained on 27 of the 33 products in use. Such results obtained over the past four years reveal that chloride contamination has occurred at 38 percent of the test areas following an average of 3.7 winters of deicing chemical applications. Contamination above base levels averaged 88 ppm or 0.35 pounds of chloride per cubic yard of concrete in the top inch of contaminated samples. The difficulty of obtaining a satisfactory seal along curb lines was evidenced by the detection of contamination in 54 percent of all cores taken at the one foot offset.

The hot applied materials have provided the best performance to date with contamination limited to less than 1/4 pound of chloride in 24 percent of the samples after an average of 4.7 winters. The standard preformed membranes were nearly as effective with an average of less than 1/3 pound of chloride found in the top inch of 24 percent of all samples. Fair performance has been obtained with the five preformed elastometer systems selected as most promising under Phase I of NCHRP Project 12-11.

The polyurethane systems have prevented chloride intrusion at 59 percent of the test locations with one of the four products 100 percent effective through four winters of exposure. Epoxy and tar emulsion systems were generally not satisfactory with contamination found at 53 and 55 percent of all test locations.

In general, the performance of the various products has been less than satisfactory although a few of the materials have been effective enough to be considered acceptable bridge deck protective systems.

VERMONT AGENCY OF TRANSPORTATION
BRIDGE DECK MEMBRANE EVALUATION PROGRAM

JULY 1971 - OCTOBER 1978

TYPE SYSTEM	NO. OF PRODUCTS	NO. OF TRIAL BRIDGES
PREFORMED	15	38
EPOXY	7	8
HOT APPLIED	5	9
POLYURETHANE	4	7
EMULSION	2	7

TOTAL = 33 PRODUCTS ON 69 BRIDGES

LIST OF PRODUCTS APPLIED

Preformed Membrane Systems

Heavy Duty Bituthene - 65 mil reinforced rubberized asphalt
Protecto Wrap M 400 - 70 mil reinforced tar & synthetic resin modified
Royston No. 10 - 75 mil reinforced bituminous
Royston No. 10 P.V. - 75 mil prevented reinforced bituminous
Royston No. 15 - 60 mil prevented reinforced bituminous
Nordel - 65 mil reinforced non-cured hydrocarbon rubber
Hyload 125 - 125 mil pitch and poly vinyl chloride polymer
Gacoflex N-35 - 1/16 inch cured & buffed neoprene rubber
Sure-Seal Butyl - 65 mil vulcanized butyl rubber
Sure-Seal EPDM - 65 mil cured Ethylene-Propylene-Diene-Monomer
Butylfelt - 60 mil butyl rubber and felt laminate
Hydro-Ban RUN-45 - 45 mil reinforced PVC and butyl rubber
Tri-Ply - 62 mil butyl neoprene
Polyguard 860 - 60 mil reinforced tar resin
Melnar 8 - 165 mil reinforced rubberized asphalt in semi-rigid 4 by 8 foot panels

Polyurethane Membrane Systems

Polytak 165 - asphalt modified polyurethane
Bon-Lastic Membrane - tar modified polyurethane
Duralseal 3100 - 100 per cent solids polyurethane
Chevron Bridge Membrane - asphalt modified polyurethane

Thermoplastic or Thermosetting Membrane Systems

Uniroyal 6125 - 195 mil hot applied rubberized asphalt
Hot Asphalt & Glass Frabric - 5 layer built up system
NEA 4000 - 90 mil single component PVC Polymer
Petromat - - non-woven polyproplene fabric & asphalt content
Gussasphalt - 2 inch mastic type paving mixture

Epoxy Membrane Systems

Duralkote 304 - solvent cut epoxy
Duralkote 306 - coal tar modified epoxy
Duralbond 102 - 100 per cent solids epoxy
Rambond 620-S - 100 per cent solids epoxy
Rambond 223 - 100 per cent solids epoxy
Ramcoat Epoxy Paint - solvent cut epoxy
Polyastics - solvent cut epoxy

Tar Emulsion Systems

Tar Emulsion - 2 coats at 0.1-0.2 gal. per coat
Tar Emulsion & Glass Fabric - 7 layer built up system

SUMMARY OF MEMBRANE PERFORMANCE BY CLASS BASED UPON CHEMICAL ANALYSIS OF CORES

Membrane Type	Average Winters Cl^- Applied	% Cores Contaminated 0-1"	% Cores Contaminated 1"-2"	Ave. Cl^- in Contaminated Cores #/cy 0-1"	Ave. Cl^- in Contaminated Cores #/cy 1"-2"
Standard Preformed	3.4	24	8	0.32	0.31
Project 12-11 Preformed	3.0	33	10	0.58	0.42
Polyurethane	3.4	41	30	0.28	0.24
Thermoplastic or Thermosetting	4.7	24	9	0.23	0.22
Epoxy	3.2	53	28	0.32	0.21
Tar Emulsion	4.6	55	33	0.45	0.36
Weighted Average of All Systems	3.7	38	19	0.35	0.28

SUMMARY OF MEMBRANE PERFORMANCE
BY CLASS AFTER A SPECIFIC NUMBER OF
YEARS OF SERVICE

TYPE SYSTEM	WINTERS SALTED	NO. OF BRIDGES	% CORES CONTAMINATED	AVE. Cl^- IN TOP INCH OF CONTAMINATED CORES
PREFORMED MEMBRANES	2	8	4	0.22 #/cy
	3	9	10	0.25 #/cy
	4	14	28	0.40 #/cy
	5	3	100	0.46 #/cy
NCHRP PROJECT 12-11 MEMBRANES	2	5	13	0.52 #/cy
	3	5	53	0.60 #/cy
	4	3	34	0.64 #/cy
POLYURETHANE MEMBRANES	2	3	11	0.38 #/cy
	3	4	17	0.15 #/cy
	4	4	58	0.32 #/cy
	5	2	100	0.32 #/cy
THERMOPLASTIC OR THERMOSETTING	3	3	44	0.32 #/cy
	4	5	27	0.31 #/cy
	5	3	0	0
	6	2	17	0.22 #/cy
	7	2	33	0.23 #/cy
EPOXY SYSTEMS	2	6	28	0.24 #/cy
	3	8	55	0.37 #/cy
	4	8	63	0.32 #/cy
	5	1	100	0.36 #/cy
TAR EMULSION	3	4	25	0.40 #/cy
	4	6	50	0.42 #/cy
	5	6	72	0.34 #/cy
	6	2	83	0.77 #/cy
	7	2	50	0.66 #/cy

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM)		5 FEET OFF CURB Chloride Content (PPM)		15 FEET OFF CURB Chloride Content (PPM)	
				AREAS WITH CL^- INTRUSION UNDERLINED					
				0-1"	1-2"	0-1"	1-2"	0-1"	1-2"
	STANDARD PREFORMED SHEET SYSTEMS								
11	Heavy Duty Bituthene 65 Mil Preformed Sheet	3 4 5 6	34	35 84 117 143	32 53 107	36 184 89	32 164	32 35 149 102	42 43 120
24	Royston No. 10 75 Mil Preformed Sheet	2 3 4 5	28	37 48 290 105	39 40 122	35 43 78 119	34 32 52	40 53 83 150	52 37 80
25	Protecto Wrap M 400 70 Mil Preformed Sheet	2 3 4 5	28	32 112 220	46 56 95	44 43 60 151	21 42 40	37 58 75 185	40 50 35
28	Royston No. 10 75 Mil Preformed Sheet	2 3 4	61	70 100 250	50 88 83	73 53 56	67 49 49	60 70 71	56 50 58
29	Heavy Duty Bituthene 65 Mil Preformed Sheet	4	44	105	60	102	58	77	52
31	Protecto Wrap M 400 70 Mil Preformed Sheet	4	36	153	70	71	69	102	90

SUMMARY OF MEMBRANE PERFORMANCE BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM)		5 FEET OFF CURB Chloride Content (PPM)		15 FEET OFF CURB Chloride Content (PPM)	
				0-1"	1-2"	0-1"	1-2"	0-1"	1-2"
	STANDARD PREFORMED SHEET SYSTEMS								
34	Protecto Wrap M 400 70 Mil Preformed Sheet	2	52	50	55	56	50	55	54
		3		59	51	71	49	70	49
		4		60	52	65	45	76	41
36	Heavy Duty Bituthene 65 Mil Preformed Sheet	2	61	117	80	70	65	70	70
		3		79	60	48	39	38	38
		4		72	52	59	40	41	41
37	Protecto Wrap M 400	4	39	50	38	60	51	48	42
42	Protecto Wrap M 400 70 Mil Preformed Sheet	4	56	25	23	40	40	55	49
43	Protecto Wrap M 400 70 Mil Preformed Sheet	2	37	25	43	42	44	28	37
		4		42	38	32	32	60	25
45	Heavy Duty Bituthene 65 Mil Preformed Sheet	4	53	122	53	66	52	36	34
46	Royston No. 10 75 Mil Preformed Sheet	4	65	72	77	83			

AREAS WITH CL^- INTRUSION UNDERLINED

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM) 0-1"	1 FOOT OFF CURB 1-2"	5 FEET OFF CURB Chloride Content (PPM) 0-1"	5 FEET OFF CURB 1-2"	15 FEET OFF CURB Chloride Content (PPM) 0-1"	15 FEET OFF CURB 1-2"
	STANDARD PREFORMED SHEET SYSTEMS								
48	Protecto Wrap M 400 70 Mil Preformed Sheet	2 3 4	33	70 75 65	50 48 51	48 57 63	25 39 60	35 44 58	25 37 56
52	Protecto Wrap M 400 70 Mil Preformed Sheet	2	47	62	52	56		82	

AREAS WITH CL^- INTRUSION UNDERLINED

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM) 0-1"	1 FOOT OFF CURB 1-2"	5 FEET OFF CURB Chloride Content (PPM) 0-1"	5 FEET OFF CURB 1-2"	15 FEET OFF CURB Chloride Content (PPM) 0-1"	15 FEET OFF CURB 1-2"
	AREAS WITH CL^- INTRUSION UNDERLINED								
	PROJECT 12-11 PREFORMED SHEET SYSTEMS								
32	Hyload 125 125 Mil PVC Polymer	2	48	68	57	85	50	45	35
		3		60	50	54	44	348	200
		4		95	85	52	50	72	60
33	Gaco-flex N-35 65 Mil Neoprene Rubber	2	128	140	110	105	75	90	110
		3		158	137	139	63	184	129
		4		420	161	145	88	87	52
38	Sure-Seal EPDM 65 Mil EPDM Rubber	2	56	84	64	84	69	60	56
		3		97	95	110	83	122	93
		4		200	127	60	55	75	64
39	Sure-Seal Butyl 65 Mil Butyl Rubber	2	56	60	46	70	30	60	60
		3		114	105	96	51	93	68
		4		268	218	50	52	58	49
40	Butylfelt Butyl Rubber & Felt	2	44	105	70	245	195	50	60
		3		110	62	98	75	73	48
		4		59	56	54	45	39	39

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM) 0-1"	1 FOOT OFF CURB Chloride Content (PPM) 1-2"	5 FEET OFF CURB Chloride Content (PPM) 0-1"	5 FEET OFF CURB Chloride Content (PPM) 1-2"	15 FEET OFF CURB Chloride Content (PPM) 0-1"	15 FEET OFF CURB Chloride Content (PPM) 1-2"
				AREAS WITH CL^- INTRUSION UNDERLINED					
	POLYURETHANE SYSTEMS								
7	Bonlastic Membrane Tar Modified Polyurethane	3	38	63	52	46	45	45	52
		4		124	99	94	76	120	79
		5		129	106	121	115	110	86
15	Polytok 165 Asphalt Modified Polyurethane	3	37	53	40	32	37	31	38
		4		109	60	30	20	53	35
		5		118	113	109	98	120	97
17	Polytok 165 Asphalt Modified Polyurethane	2	35	29	26	36	32	30	24
		3		75	50	70	50	60	50
		4		175	126	101	65	100	90
30	Duralseal 3100 100% Solids Polyurethane	2	81	40	40	61	75	114	99
		3		60	60	70	49	57	51
		4		68	61	70	58	69	62
51	Chevron	2	44	140		68		72	
53	Chevron	2							

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM) 0-1"	1 FOOT OFF CURB 1-2"	5 FEET OFF CURB Chloride Content (PPM) 0-1"	5 FEET OFF CURB 1-2"	15 FEET OFF CURB Chloride Content (PPM) 0-1"	15 FEET OFF CURB 1-2"
	AREAS WITH CL^- INTRUSION UNDERLINED								
	THERMOPLASTIC OR THERMOSETTING SYSTEMS								
2	Uniroyal 6125 Hot Rubberized Asphalt	4	41	52	56	82	50	63	51
		5				50	38	48	38
		6		50	43	60	54	48	35
		7		57	48	57	55	43	35
4	Uniroyal 6125 Hot Rubberized Asphalt	4	39	60	51	35	33	46	37
		5		61	57	50	40	55	60
		6		55	30	95	90	35	35
		7		68	31	95	45	100	58
18	Hot Asphalt & Glass Fabric	2	21	57	43	24	32	42	29
		3		175	55	78	75	65	45
		4		165	82	88	80	75	70
20	Hot Asphalt & Glass Fabric	2	26	26	31	21	27	32	32
		3		68	50	66	61	94	64
		4		53	50	50	48	58	53
		5		74	60	77	67	69	61
35	NEA 4000 Hot PVC Polymer	2	60	70	66	93	66	61	61
		3		97	90	71	59	88	60
		4		100	64	86	80	78	72
50	Petromat	2	33	105	61	57	48	80	70

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM) 0-1"	1 FOOT OFF CURB 1-2"	5 FEET OFF CURB Chloride Content (PPM) 0-1"	5 FEET OFF CURB 1-2"	15 FEET OFF CURB Chloride Content (PPM) 0-1"	15 FEET OFF CURB 1-2"
				AREAS WITH CL^- INTRUSION UNDERLINED					
	EMULSION SYSTEMS								
1	Tar Emulsion	4	32	138	67	37	35	43	44
		5		149	66	60	60	25	25
		6		493	224	100	68	95	75
		7		230	128	62	58	70	57
3	Tar Emulsion	4	31	164	136	36	33	35	34
		5		186	125	85	80	150	85
		6		328	175	100	50	67	44
		7		286	130	45	38	78	57
6	Tar Emulsion & Glass Fabric	3	33	86	67	42	35	46	35
		4		75	50	85	75	100	60
		5		115	105	90	85	79	69
		6							
8	Tar Emulsion & Glass Fabric	3	30	48	35	118	66	61	45
		4		50	23	58	17	65	35
		5		60	30	65	58	66	26
		6							
12	Tar Emulsion & Glass Fabric	3	29	56	48	52	45	46	29
		4		215	148	185	168	152	123
		5		240	106	90	65	83	66
		6							
14	Tar Emulsion & Glass Fabric	3	25	183	85	38	40	45	45
		4		106	45	33	24	33	50
		5		108	73	82	58	68	59
		6							

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM)		5 FEET OFF CURB Chloride Content (PPM)		15 FEET OFF CURB Chloride Content (PPM)	
				AREAS WITH CL^- INTRUSION UNDERLINED					
				0-1"	1-2"	0-1"	1-2"	0-1"	1-2"
	EPOXY SYSTEMS								
9	Duralkote 304 Solvent Cut Epoxy	3	39	296	89				
		4		109	75	126	106	50	29
10	Duralkote 306 Coal Tar Modified Epoxy	3	32	117	64	82	84	109	81
		4		135	80	114	90	50	50
		5		135	105	118	80	116	67
16	Duralkote 102 100% Solids Epoxy	2	35	50	31	55	36	22	41
		3		68	46	55	41	62	63
		4		121	113	94	74	108	55
19	Rambond 620-S 100% Solids Epoxy	2	25	78	58	45	39	43	29
		3		117	42	65	47	56	46
		4		140	80	90	50	48	48
22	Polyastics Solvent Cut Epoxy	2	27	127	69	38	34	55	39
		3		103	36	46	38	55	43
		4		80	72	62	58	69	60
23	Duralkote 306 Coal Tar Modified Epoxy	2	26	30	29	40	35	39	32
		3		50	55	70	63	75	48
		4		100	90	55	51	45	41

SUMMARY OF MEMBRANE PERFORMANCE
BASED UPON CHEMICAL ANALYSIS OF CORES

BRIDGE NO.	MEMBRANE SYSTEM	WINTERS CL^- APPLIED	BASE CL^- LEVEL (PPM)	1 FOOT OFF CURB Chloride Content (PPM)		5 FEET OFF CURB Chloride Content (PPM)		15 FEET OFF CURB Chloride Content (PPM)	
				AREAS WITH CL^- INTRUSION UNDERLINED					
				0-1"	1-2"	0-1"	1-2"	0-1"	1-2"
				EPOXY SYSTEMS					
26	Ramcoat Epoxy Paint	2	50	115	80	90	75	64	70
	Solvent Cut Epoxy	3		128	112	118	28	254	72
		4		125	102	120	40	161	80
27	Rambond 223	2	50	96	66	75	50	64	30
	100% Solids Epoxy	3		60	35	60	40	55	35
		4		65	58	85	58	80	55

MEMBRANE EVALUATION SUMMARY

Membrane Type	Ease of Application	Flexibility	Bond & Seal at Curb	Blisters or Pinholes	Bond between Concrete Membrane & Pavement	Problems with Pavement Application	Cost per sy	Overall Performance	Recommendation
Standard Preformed	easy	good	fair	yes/ no	fair/ good	occ.	$ 4.50	good	Continue Use
Miscellaneous Preformed	easy	good	poor	yes/ no	poor/ fair	yes	$ 5.00	poor	Not recommended for use
Project 12-11 Preformed	hard	exc.	fair	yes/ no	good/ good with prot. boards	yes	$10.65	fair to good	Not recommended unless other systems prove to be unsat.
Polyurethane	easy	good	exc.	no/ yes	good/ poor	occ.	$ 5.19	fair	Restrict Use
Thermoplastic or Thermosetting	hard	poor to good	fair	no/ yes	fair/ fair	occ.	$ 4.00	good	Consider further use
Epoxy	easy	poor	fair	no/ yes	good/ poor	no	$ 9.42	poor	Not recommended for use
Emulsion	very easy	poor	poor	no/ no	good/ good	no	$1.32/ $3.50	poor	Restrict Use

AGENCY OF TRANSPORTATION
~~HIGHWAY DEPARTMENT~~

OFFICE MEMORANDUM

TO: COMMISSIONER, CHIEF ENGINEER, DIVISION HEADS, & DIST. TRANSPORTATION ENGINEERS

FROM: R. F. Nicholson, P.E., Materials & Research Engineer

DATE: November 14, 1978

SUBJECT: Field Performance of Experimental Bridge Deck Membrane Systems

Enclosed for your information is a copy of a paper presented at the Northeastern States Materials Engineers Meeting held October 24 and 25, 1978. The paper covers field performance results obtained on experimental membrane systems applied in Vermont over the past eight years.

Significant findings stated in the paper include the following:

Vermont's evaluation program currently includes 33 different membrane systems applied on 69 new bridge decks. No further experimental applications are anticipated in the immediate future.

Field performance results have been obtained on 27 of the 33 systems in use. Such results reveal that chloride contamination has occurred at 38 percent of the test areas following an average of 3.7 winters with contamination averaging 0.35 pounds of chloride per cubic yard of concrete in the top inch of contaminated samples.

The best performance to date has been provided by the hot applied materials and the standard preformed membranes with contamination limited to 24 percent of all cores taken on both classes of materials.

The control treatment consisting of tar emulsion with or without glass fabric has offered the least protection with contamination averaging 0.45 pounds of chloride recorded in 55 percent of the samples tested.

In general, the performance of the various products has been less than satisfactory although a few of the materials have been effective enough to be considered acceptable bridge deck protective systems.

This paper is being supplied for your information. If you do not wish to retain a copy for your files, please return it to the Materials & Research Division.

Enclosure

RFN/msd
cc: RFN/Lab File
R. Frascoia
Central Files

PROTECTO-WRAP M-400

I-91 SB Over State Aid No. 1

April 1973

Checking the puncture resistance of preformed sheet membranes subjected to applications of 275°F - 325°F bituminous mixes applied at a load of 200 psi.

Air bubbles in the solvent cut prime coat were broken with a squeegee prior to placing the membrane sheets.

Pressing the membrane into the mastic at the curb line with a one inch diameter wallpaper roller.

Rolling the membrane and removing the polyethylene film to expose the self sealing edge.

HOT MOPPED ASPHALT & GLASS FABRIC

I-91 NB Over State Aid No. 9

May 1973

Bubbles up to 3/4 inch in diameter appeared in the cutback asphalt prime coat shortly after application.

Placing glass fabric in the first coat of asphalt along the curb. Note moisture sensing copper foil strips placed beneath the membrane to detect the passage of moisture.

Placing glass fabric in first coat of hot asphalt.

Bubbles and pinholes in the first coat of asphalt.

RAMBOND 620-S EPOXY

I-91 SB Over State Aid No. 9

April 1973

The application of multiple coats of epoxy reduced but did not eliminate all pinholes.

Electrical resistance readings averaged 41,500 ohms per square foot which indicates that some of the holes were open to the concrete.

POLYASTIC'S EPOXY
I-91 NB Over Town Highway No. 9

Bubbles formed in the epoxy coating 16 to 20 hours after application.

Cohesive cracks occurred in a field applied coating 6 months after application.

HOT MOPPED ASPHALT & GLASS FABRIC

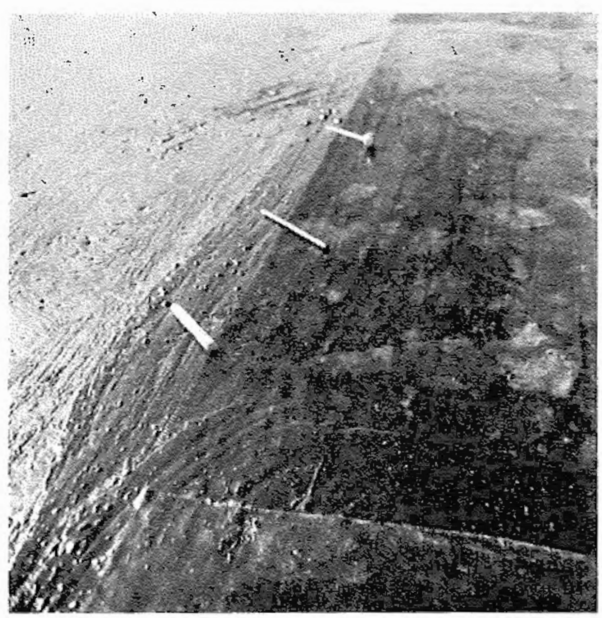
I-91 NB Over State Aid No. 9

May 1973

Bubbles up to ¾ inch in diameter appeared in the cut-back asphalt prime coat shortly after application.

Placing glass fabric in the first coat of asphalt along the curb. Note moisture sensing copper foil strips placed beneath the membrane to detect the passage of moisture.

Placing glass fabric in first coat of hot asphalt.



Bubbles and pinholes in the first coat of asphalt.

PROTECTO WRAP M400

I 91 SB OVER STATE AID NO. 1

Deck paved April 20, 1973   Pictures taken July 3, 5, 1973

Low electrical resistance readings indicate damage to the membrane at some locations.

Membrane exposed when truck braked on deck