VERMONT DEPARTMENT OF HIGHWAYS

EVALUATION OF BRIDGE DECK MEMBRANE SYSTEMS AND MEMBRANE EVALUATION PROCEDURES

June 1975

"Statement of Work"

PREFACE

The need to protect bridge decks from damage caused by deicing chemicals and moisture has been well established. The most widely used method is the membrane system, which is designed to seal the deck surface thus preventing moisture and chloride intrusion. Although the use of membranes has increased greatly during the past several years, four important questions remain unanswered at this time. They are as follows:

1. Can the performance of a membrane system be evaluated with non-destructive tests?

2. What is the relation between non-destructive test results and actual membrane performance as indicated by chemical analysis of recovered cores?

3. Is a protective layer required over a membrane to insure satisfactory long-term performance?

4. Which membrane system is most effective?

In answer to question 1, some states are rejecting membranes based on test results which have never been directly related to actual physical performance of a membrane system. Any determination of the relation between test results and actual physical performance, in question 2, would provide a valuable tool to organizations attempting to evaluate experimental membrane systems. In answer to question 3, states are depending upon various industry claims to determine the need for protection. Answers to these first three questions would provide the basis for determining the most effective membrane system in answer to question 4.

Vermont began installing experimental membrane systems in 1971, with applications on six new bridges and now has a total of twenty-six different membrane materials on forty-nine bridge decks. As newly constructed bridges were selected for experimental membrane applications, initial tests were conducted to determine the average steel potential readings and cores were taken to determine the initial chloride content of the new concrete. As the membrane systems were placed, copper foil strips were installed beneath the materials and electrical resistance readings were taken on the membranes and on the completed pavement-membrane systems.

Selective progress testing and evaluation by Vermont has indicated that the answers to the above four questions could be obtained with carefully controlled and greatly expanded progress testing using the initial test results as a base. This would provide an opportunity to exploit five year old data into short-range conclusions.

OBJECTIVES

1. To identify the limitations of the non-destructive tests currently being used to evaluate the effectiveness of bridge deck membrane systems.

2. To determine the relation between test results and actual membrane performance.

3. To evaluate the need for protective layers on membranes for long-term performance.

4. To evaluate the effectiveness of twenty-six membrane systems.

SCOPE

Work involves testing twenty-three bridges in calendar 1975 and a minimum of thirty-nine bridges in 1976 in order to meet the objectives. The tests shall include electrical resistivity and copper foil strip readings, electrical potential measurements and the recovery of concrete samples for chemical analysis.

DELINEATION OF CONTRACTOR TASKS

The contractor shall, in pursuit of the contract objective, perform the following tasks:

TASK A: Survey and test bridges as noted in the "Work Plan" and "Schedule of Proposed Work".

Step 1: Electrical resistivity tests will be taken to measure membrane permeability, using the frequency and location in the work plan.

Step 2: Electrical potential readings will be taken to determine corrosion activity,using the frequency and location in the work plan.

Step 3: Test cores will be taken and analyzed for chlorides, using the work plan frequency and location.

TASK B: Summarize all test results for each bridge in tabular or graphic form.

Step 1: Resistivity readings by the California method will be contoured for each bridge on a plan sheet. Resistivity readings by moisture strips will be located on steel potential and other resistivity contour sheets.

Step 2: Electrical potential readings will be contoured for each bridge on a plan sheet.

Step 3: Chloride content will be tabulated showing locations and depth for each bridge and located on steel potential and resistivity contour sheets.

TASK C: Summarize all test results in 1975 in a form showing conclusions to the following:

Step 1: Can non-destructive tests be used to evaluate membrane systems?

Step 2: What is the relation between test results and membrane performance?

Step 3: Is a protective layer needed?

Step 4: Is there a measurable difference in performance between different membrane systems?

TASK D: Revise and finalize Task C based on 1976 data and submit a final report.

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"Work Plan"

OBJECTIVE OF STUDY

The objective of the study will be to obtain the following information:

1. To identify the limitations of the non-destructive tests currently being used to evaluate the effectiveness of bridge deck membrane systems.

2. To determine the relation between test results and actual membrane performance.

3. To evaluate the need for protective layers on membranes for long-term performance.

4. To evaluate the effectiveness of twenty-six membrane systems.

TEST PROCEDURES

All testing shall be in accordance with or equal to that described in FHWA Demonstration Project Number 33.

Tests shall include electrical resistivity readings, copper foil strip resistance readings, electrical potential measurements and the recovery of concrete cores for chemical analysis.

The electrical resistivity tests and electrical potential measurements shall be taken at 5-foot intervals covering a minimum of 50 lineal feet of each deck. The test area shall include a minimum of one-half of the deck width. A minimum of 3 cores shall be taken from each deck, with the samples taken at resistivity and steel potential test locations. Additional cores may be taken from areas where widely varying electrical resistance and/or electrical potential readings are noted.

WORK LOCATION

Field tests will be conducted at the following locations:

Area I — U. S. Route 4 in Fair Haven-Castleton, Vermont.

Area II — Interstate 91 in Barton-Derby, Vermont.

Area III — Interstate 91 in Lyndon-Barton, Vermont.

Area IV — Interstate 91 in Bradford-Ryegate, Vermont.

Area V — Route 9 in Bennington, Vermont; Route 62 in Barre, Vermont; Berlin State Highway in Berlin, Vermont.

SCHEDULE OF PROPOSED WORK

The study shall include the testing of 23 bridge decks in calendar 1975 and a minimum of 39 bridge decks in 1976. Additional bridges or alternates will be included in the study if initial results indicate the need for further information.

See Attachment Number 1 for the schedule of the proposed work.

ESTIMATE OF COST

The cost of the study shall include field testing, chemical analysis of concrete samples and the tabulation and reporting of the data obtained. The cost shall not exceed $9,969.00.

See Attachment Number 2 for a cost breakdown of the proposed work.

FINAL REPORT

The final report shall include a summary of all test results for each bridge, in tabular or graphic form. Conclusions will be drawn from the test data to complete the objectives. The final report will be submitted as soon as all of the data has been obtained and recorded.

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"Schedule of Proposed Work"
1975 - 1976

Structure - System No.	System	Structure	Resistivity Test	Date Completed	1/2 Cell Potential	Date Completed	Core Recovery	Date Completed	Chemical Analysis	Date Completed	Plot & Summarize Test Result	Date Completed
			AREA I Fair Haven-Castleton, Vt.									
1	2-Coats Tar Emulsion	US 4 WB/ Rt. 30	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		1/76 6/76	
2	Uniroyal	US 4 EB/ Rt. 30	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		1/76 6/76	
3	2-Coats Tar Emulsion	US 4 WB/ Rt. 30	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		1/76 6/76	
4	Uniroyal	US 4 EB/ Rt. 30	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		1/76 6/76	
			AREA II Barton-Derby, Vt.									
6	Tar Emulsion & G.F.	I 91 NB/ SA #2	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		2/76 6/76	
7	Bonlastic	I 91 SB/ SA #2	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		2/76 6/76	
8	Tar Emulsion & G.F.	I 91 NB/ TH #40	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		2/76 6/76	
9	Duralkote 304	I 91 SB/ TH #40	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		2/76 6/76	
10	Duralkote 306	I 91 NB/ TH #29	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		2/76 6/76	
11	H.D. Bituthene	I 91 SB/ TH #29	7/75 4/76		7/75 4/76		7/75 4/76		8/75 4/76		2/76 6/76	
12	Tar Emulsion & G.F.	I 91 NB/ Rt. 5	7/75 5/76		7/75 5/76		7/75 5/76		8/75 5/76		2/76 6/76	
14	Tar Emulsion & G.F.	I 91 NB/ Barton-Orleans River	7/75 5/76		7/75 5/76		7/75 5/76		8/75 5/76		2/76 6/76	
15	Polytok 165	I 91 SB/ Barton-Orleans River	7/75 5/76		7/75 5/76		7/75 5/76		8/75 5/76		2/76 6/76	
			AREA III Lyndon-Barton, Vt.									
16	Duralbond 102	I 91 NB/ US 16	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	

(con't)

EVALUATION OF BRIDGE DECK MEMBRANE SYSTEMS

AND MEMBRANE EVALUATION PROCEDURES

"Schedule of Proposed Work"
1975 - 1976

Structure - System No.	System	Structure	Resistivity Test	Date Completed	1/2 Cell Potential	Date Completed	Core Recovery	Date Completed	Chemical Analysis	Date Completed	Plot & Summarize Test Result	Date Completed
17	Polytok 165	I 91 SB/ US 16	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
18	Hot Mopped Asphalt & G.F.	I 91 NB/ SA #9	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
19	Rambond 620-S	I 91 SB/ SA #9	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
20	Hot Mopped Asphalt & G.F.	I 91 NB/ Rt. 122	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
22	Polyastics	I 91 NB/ TH #9	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
23	Duralkote 306	I 91 SB/ TH #9	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
24	Royston # 10	I 91 NB/ SA #1	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
25	Protecto-Wrap	I 91 SB/ SA #1	8/75 6/76		8/75 6/76		8/75 6/76		12/75 6/76		3/76 7/76	
		AREA IV Bradford-Ryegate, Vt.										
26	Ramcoat Epoxy Paint	I 91 SB/ Rt. 25	7/76		7/76		7/76		8/76		8/76	
27	Rambond 223	I 91 NB/ Rt. 25	7/76		7/76		7/76		8/76		8/76	
28	Royston # 10	I 91 NB/ Waits River	7/76		7/76		7/76		8/76		8/76	
29	H.D. Bituthene	I 91 SB/ Waits River	7/76		7/76		7/76		8/76		8/76	
30	Duralseal 3100	I 91 NB/ Rt. 25B	7/76		7/76		7/76		8/76		8/76	
31	Protecto-Wrap	I 91 SB/ Rt. 25B	7/76		7/76		7/76		8/76		8/76	
32	Hyload 125	I 91 NB/ TH #6	7/76		7/76		7/76		8/76		8/76	

(con't)

EVALUATION OF BRIDGE DECK MEMBRANE SYSTEMS

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"Schedule of Proposed Work"
1975 - 1976

Structure - System No.	System	Structure	Resistivity Test	Date Completed	1/2 Cell Potential	Date Completed	Core Recovery	Date Completed	Chemical Analysis	Date Completed	Plot & Summarize Test Result	Date Completed
33	Gacoflex	I 91 SB/ TH #6	7/76		7/76		7/76		8/76		8/76	
35	NEA 4000	I 91 SB/ SA #1	7/76		7/76		7/76		8/76		8/76	
38	1/2 EPDM Carlisle	I 91 NB/ Wells River	7/76		7/76		7/76		8/76		8/76	
39	1/2 Butyl Carlisle	I 91 NB/ Wells River	7/76		7/76		7/76		8/76		8/76	
40	Butylfelt	I 91 SB/ SA #5	7/76		7/76		7/76		8/76		8/76	
41	Chevron	TH #61/ I 91	7/76		7/76		7/76		8/76		8/76	
	AREA V Bennington, Barre, Berlin, Vt.											
43	Protecto-Wrap	WB Vt.9/ 67A	8/76		8/76		8/76		9/76		9/76	
47	Nordel	WB Vt.9/ RR	8/76		8/76		8/76		9/76		9/76	
48	Protecto-Wrap	Ramp A Berlin	8/76		8/76		8/76		9/76		9/76	
49	Gussasphalt	Rt. 62/ Black-well St.	8/76		8/76		8/76		9/76		9/76	

EVALUATION OF BRIDGE DECK MEMBRANE SYSTEMS

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"Estimate of Cost"
1975 - 1976

Calendar 1975

Field Testing		
23 bridges at 1.25 mandays per bridge ($48.00 per manday)	=	$ 1,380.00
Mileage and/or Equipment Rental		
	=	490.00
Chemical Analysis of Concrete Samples		
23 bridges x 4.5 average cores per bridge x 2 samples per core ÷ 8 samples per manday ($54.00 per manday).	=	1,397.00
Tabulation and Reporting of Results		
5 days ($64.00 per manday).	=	320.00
Total 1975 Cost	=	$ 3,587.00

Calendar 1976

Field Testing		
39 bridges at 1.25 mandays per bridge ($51.00 per manday)	=	$ 2,486.00
Mileage and/or Equipment Rental		
	=	735.00
Chemical Analysis of Concrete Samples		
39 bridges x 4.5 average cores per bridge x 2 samples per core ÷ 8 samples per manday ($57.00 per manday).	=	2,501.00
Tabulation and Reporting of Results		
10 days ($66.00 per manday).	=	660.00
Total 1976 Cost	=	$ 6,382.00

TOTAL ESTIMATED STUDY COST	=	$ 9,969.00