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**RESEARCH UPDATE**

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Update U96-19

**MEASURING CORROSION WITH EMBEDDED PROBES**

**REFERENCE:**

Work Plan 88-R-7

**HISTORY:**

The Vermont Agency of Transportation installed eight (8), three-electrode linear polarization (3LP) probes manufactured by K.C. Clear, Inc. of Sterling, VA, in seven bridge decks on I-91 and I-89 during various interstate deck repair projects in the summer of 1990. The objective was to evaluate the ability of waterproofing membranes to arrest corrosion in bridge decks that had suffered chloride contamination. A secondary objective was to evaluate the practicality and reliability of the probe installations. The probes were placed adjacent to two #5 reinforcing steel bars, with the probe wires strung back to a sealed junction box that had been mounted on the nearest abutment. Periodic testing has occurred since then. The following bridges were included in the study:

189 Br 6N	Hartford	9/28/90	191 Br 16N	Putney	5/22/90
189 Br 6S	Hartford	7/13/90	191 Br 18S	Putney (2 Probes)	8/15/90
191 Br 14N	Putney	5/16/90	191 Br 22N	Rockingham	5/10/90
			191 Br 22S	Rockingham	6/06/90

**TEST PROCEDURES:**

The 3LP probe system allows the application of a measured current change to a rebar adjacent to the embedded probe via a counterelectrode in the probe. If a large current is required to change the potential, this means that the corrosion rate is high. Conversely, the corrosion rate would be rated low if a small current is required. The readings are then entered into a computer program, which gives the corrosion rate in mA/sq ft.(ICORR). The readings are time dependent and can vary greatly depending on temperature, moisture, and other factors.



INSTALLATION OF PROBES IN BRIDGE DECK

**STATUS:**

During the past 65 months, ending on April 29, 1996, the following readings were observed:

**ICORR in mA/sq ft**

Date	I89		I91					
	6N	6S	14N	16N	18S(N)	18S(S)	22N	22S
08/31/91	7.16	12.56	10.02	12.04	16.40	10.12	15.03	11.69
10/13/91	7.17	9.28	8.70	12.54	13.60	9.60	10.85	9.30
06/25/92	6.40	9.34	8.70	10.23	10.43	8.66	12.51	10.56
07/13/93	6.04	10.43	8.62	9.35	11.04	8.23	11.57	10.29
09/24/94	6.36	7.53	5.40	4.47	5.08	6.84	7.62	7.06
12/23/94	2.84	6.05	6.97	2.63	3.46	3.96	3.92	3.86
06/05/95	4.75	9.37	6.70	5.02	7.32	8.26	8.70	8.27
08/30/95	3.79	6.78	5.17	3.67	5.91	6.27	6.60	5.96
11/30/95	1.89	3.92	2.08	1.78	2.32	3.26	2.61	3.12
04/29/96	2.42	6.34	3.54	2.74	4.26	4.70	4.21	4.38

On June 14, 1995, personnel from the Materials and Research Division, and FHWA Demonstration Project 84 personnel jointly conducted tests on Bridges 6S and 6N on I-89, which yielded comparable ICORR readings.

**DISCUSSION:**

The most current interpretation of the values obtained from rate of corrosion measurement equipment comes from the Strategic Highway Research Program (SHRP) research studies which suggest the following guidelines:

For ICORR < 0.1 mA/ft<sup>2</sup>, the steel is passive

For ICORR >= 0.1 mA/ft<sup>2</sup>, the steel active or partially active

K.C. Clear, Inc. also suggests that values over 2 mA/sqft will result in concrete delamination within a 2 year period.

If the SHRP and Clear guidelines are used, the values obtained at the Vermont probe locations suggest a very high level of corrosion activity with a gradual reduction over time. The fact that all locations had high ICORR results raises questions about the validity of these values. Furthermore, field inspections have not revealed any other visual evidence of deck distress. Due to the questions raised, no conclusions should be drawn regarding the performance of the waterproofing membrane until more extensive testing has been completed.

**FOLLOW UP:**

Collection of data will continue in an effort to validate the effectiveness of both the waterproofing membranes and the 3LP equipment. At some future date, it may be necessary to conduct destructive testing (removal of pavement, membrane and concrete) to check the respective rebars for signs of corrosion.