EVALUATION OF EPOXY COATED REINFORCING STEEL

by

W. T. McKeel, Jr.
Research Engineer

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Epoxy coated deck reinforcement was evaluated during the construction of two bridges on Rte. I-77 in Carroll County. The contractor was favorably impressed with the coated steel, which sustained no damage during shipping or deck construction. Among the data collected were resistivity and potential readings, initial chloride contents of the deck concrete, and unit costs. It appears that the epoxy coatings had many small bare spots and other flaws that were not effectively patched at the site. Further evaluations after the bridges are opened to traffic and subjected to applications of deicing salts are recommended.

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INTRODUCTION

The spalling of concrete bridge decks due to corrosion of the reinforcing steel in the presence of chloride ions from deicing salts is a national problem that has received wide attention. One promising approach to a solution is the use of reinforcing steel with a thin coating, approximately 7 mils (0.18 mm) in thickness, of an epoxy compound. Developed by the National Bureau of Standards under a Federal Highway Administration (FHWA) research contract, the coatings were found in laboratory studies to provide an inert barrier sufficiently tough to allow bending of the bar and to withstand the abuse of normal construction handling.

Satisfied with the laboratory performance of the coated steel, the FHWA encouraged its use and evaluation in field installations. Such a trial was made by the Virginia Department of Highways and Transportation on two bridges in Carroll County, and that experimental installation is the subject of this report.

PURPOSE AND SCOPE

The purpose of the subject study was to evaluate a trial installation of epoxy coated reinforcing steel on the twin bridges carrying Route I-77 over Route 620 in Carroll County.

The study was intended to determine any problems encountered during the fabrication and shipping of the steel and during the placement of the deck concrete on the bridges. An evaluation of the performance of the steel under exposure to deicing salts for a period of approximately two years after construction was initially proposed, but proved impossible as the road has not yet been opened to traffic. Base data were obtained on the bridges, and further evaluation of the effectiveness of the steel after the application of deicing salts is recommended.

The initial research effort included observation of the deck construction and the obtaining of electrical resistivity and potential measurements, concrete cover depth data, and the base chloride contents of the concrete, all of which are discussed in this report. Although a control structure was not included in the initial proposal, base chloride contents were determined for the decks of two nearby bridges with uncoated steel for use in future comparisons with the performance of the coated steel.

TEST BRIDGES

The structures chosen for the initial use of epoxy coated deck reinforcement were the essentially identical bridges carrying Route I-77 over its southern crossing of Route 620 twelve miles north of the North Carolina state line in Carroll County. Each bridge is composed of steel beams, continuous over 3 spans nominally 52'-0", 73'-6", and 52'-0", (15.8, 22.4, and 15.8 m) in length for a actual total length of 179'-6¼"(54.7 m). Both structures are skewed at 8° (0.140 rad) and both have clear roadway widths of 52'-0" (15.8 m) face-to-face of parapets. Details of the bridges are shown in Plans CCXVI-2, Virginia Department of Highways and Transportation.

All of the transverse and longitudinal steel in both decks, including the negative moment reinforcement over the piers was coated, but uncoated steel was used in the parapets. Each of the bridges required 69,277 lb. (31,424 kg) of coated reinforcing steel. The longitudinal and main transverse reinforcement was number 5 (15 mm) bars. Number 6 (19 mm) bars were placed longitudinally over the piers to accommodate negative moment tensile forces in the slab and number 7 (22 mm) bars were placed transversely at the ends of the slabs.

The main transverse reinforcement consisted of straight bars with hooked ends in the top and bottom mats, alternating with bent "truss" bars and spaced to provide a line of reinforcement every 5" (127 mm). The transverse bars were placed on the 8° (0.140 rad) skew.

Coating of the reinforcement was specified by the Virginia Department of Highways and Transportation's "Special Provision for Epoxy Coated Reinforcing Steel" (see Appendix), which closely paralleled guidelines suggested by the FHWA. The special provisions required the use of plastic or plastic-coated chairs and tie-wires. Four epoxy coating materials, prequalified by the FHWA, were allowed by the special provisions. SKOTCHKOTE 202, manufactured by the Minnesota Mining and Manufacturing Company and applied by Rossen-Richards of North Carolina, was used on the test bridges.

As is commonly done in the case of continuous bridges, a pouring sequence (Figure 1) was specified on the plans. The five placement areas, separated by construction joints and placed at different times, were treated as units in planning the experimental evaluation.

CONTROL DECKS

Epoxy coated reinforcement was specified throughout the decks of both the test bridges, which allowed no direct comparison with the performance of uncoated reinforcement. Since it was believed desirable to have a control deck, the closest nearby structures on Route I-77 were chosen. These were the two bridges over Route 775, north of the experimental bridges; there are no other structures on the interstate highway in Virginia south of Route 620.

The Route 775 bridges represent both lanes of the interstate, and they are scheduled for opening November 1, 1977, versus July 1, 1977, for the experimental bridges. Thus, both sets of structures can be expected to experience similar salt application histories. There are, however, differences between the two sets of bridges. They were built by different contractors, of concrete from different plants, and are different types of structures. While the test bridges over Route 620 are continous spans on steel beams, the Route 775 bridges are made up of more rigid, simply supported, reinforced concrete tee-beam spans. While the control structures do not represent an ideal comparison, it is believed that valuable data can be obtained, since the evaluations will include the determination of the amount of chloride in the deck of both sets of bridges.

While construction data will be available in the files, the only field data taken on the control decks have been the base chloride contents presented in this report.

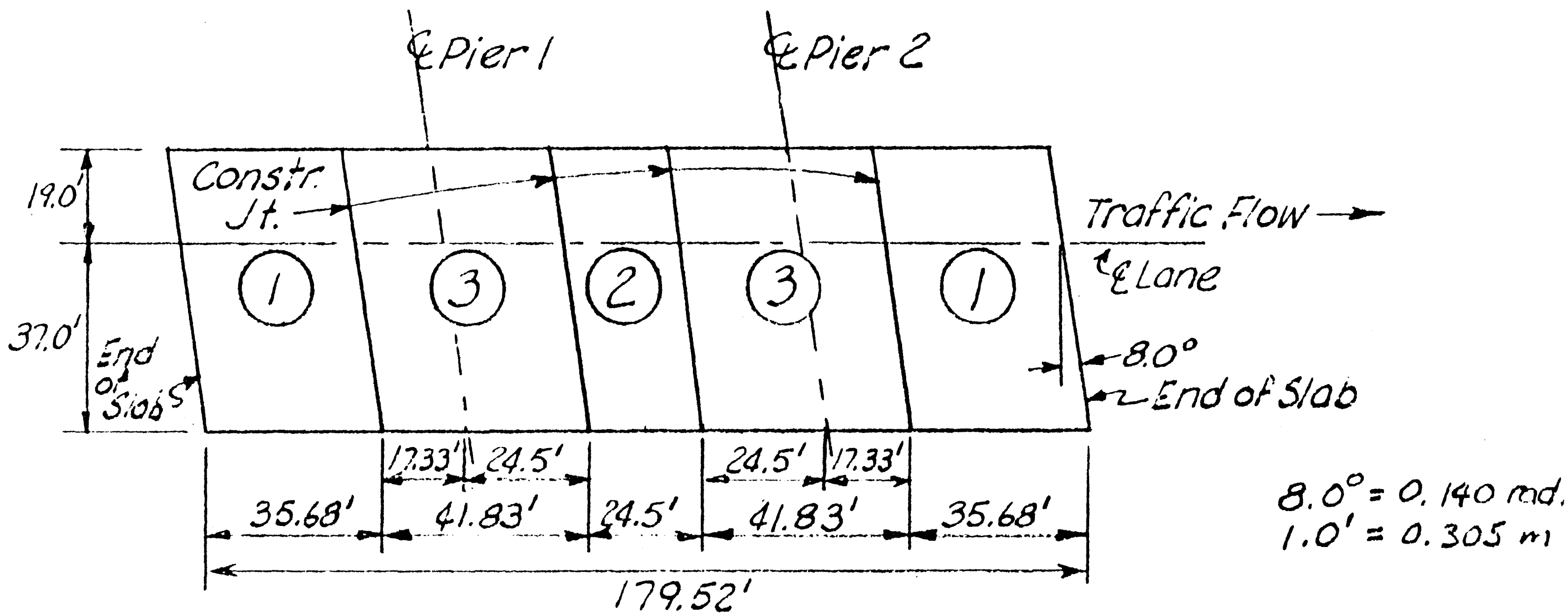

Figure 1. Typical pouring sequence with bridge dimensions.

INSTRUMENTATION

As mentioned earlier, the evaluation techniques used in this study included resistivity readings to determine the condition of the coating and electrical potential measurements to indicate active corrosion of the steel. Because the epoxy coating is a nonconductive barrier on the surface of the steel, it was necessary to provide an electrical connection to the steel prior to placement of the deck concrete.

Two wires were attached to selected transverse bars in the top reinforcing mat by means of self-tapping screws as shown in Figure 2. The purpose of the two wires was to provide verification that a circuit existed if an infinite resistivity was read; otherwise, the infinite reading could be caused by an incomplete circuit due to breakage of a wire during deck construction. It was found that the self-tapping screw was most easily installed by drilling a hole in the bar with a small diameter pilot bit, followed by a bit of the proper diameter for the screw. To provide insulation, the connection was coated with a liquid epoxy compound furnished by the supplier of the coating. The wires were run along the parapet reinforcement, to which they were secured, and through a 1/2-inch (13 mm) inside diameter plastic conduit in the top of the parapet. The plastic conduit was subsequently cut off close to the top of the parapet and capped.

In this manner, the electrical connection was easily provided and it is suggested that such a feature be incorporated into any deck if potential measurements are desired later in the life of the bridge. If a connection is made at the time of construction, it will not be necessary later to locate and uncover a bar in the surface of the deck.

Two lines of straight bars in each of the five placement areas in both bridges were wired. Since the bars lap near the center of the roadway, a double-wired connection was placed on each side, so there are 20 wiring locations on each bridge. This should provide sufficient data for an adequate evaluation of the effectiveness of the coated steel.

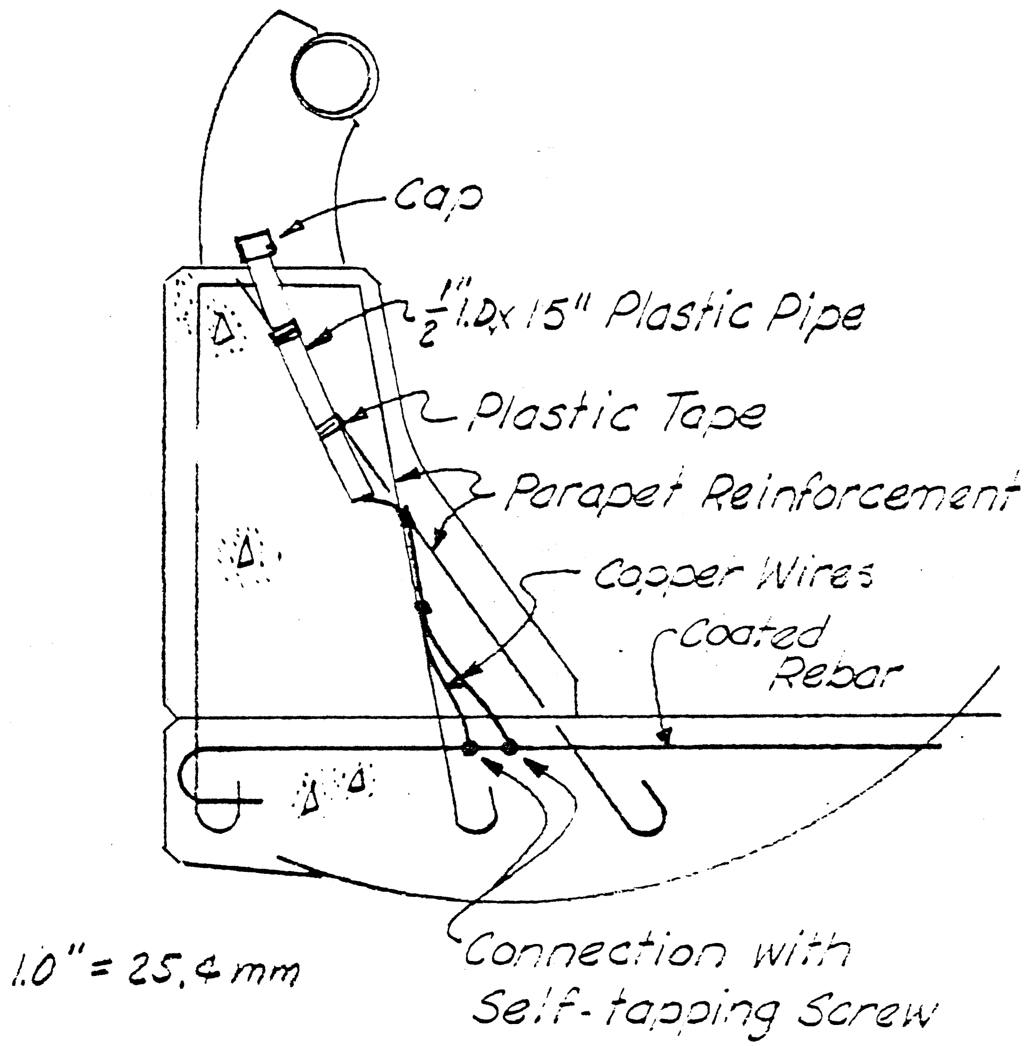

Figure 2. Attachment of wires for electrical connection to coated steel.

REINFORCING BAR PREPARATION AND CONDITION

It was desirable to patch the coatings of a number of the bars to attain a complete barrier. This was done to allow an evaluation of the susceptibility of the coating to damage during construction through initial resistivity readings. Because of the large number of bars which had been wired, it was decided to attempt to completely patch those bars designated by "R" in Figures 3 and 4. The remaining bars were given no preparation beyond the patching required of the contractor by the state inspectors. The completely coated bars were tested for defects in their coatings using an ohmmeter, and were patched with a compatible liquid epoxy system supplied with the bars.

It was apparent that virtually none of the bars should have passed the strigent requirements of the special provisions, which state, in part:

> The coating shall be checked after cure for continuity of coating and shall be free from holes, voids, contamination, cracks, and damaged areas. There shall not be more than two holidays [pinholes not visually discernible] in any linear foot [0.3 m] of the coated bar.

Visual inspection of the bars showed many small bare areas on the deformations, and the appearance of the edges of these areas indicated that the coating had been rubbed off prior to curing. Further checking with the ohmmeter discolosed many pinholes, and substantial patching along the full length of all the bars was required. The bars were coated with the liquid epoxy at the time of checking with the ohmmeter. Circumstances did not allow rechecking after coating and before installation.

RESISTIVITY READINGS

Resistivity readings were taken at intervals of 5'(1.5 m) along the lengths of the instrumented bars, beginning at a point 1' (0.30 m) from the face of the curb. Thus, as indicated in Tables 1 and 2 for the two bridges, readings were obtained at 11 points on each line across the 52' (15.8 m) wide deck. The straight transverse bars to which electrical connections were made lap between points 6 and 7 on both decks. The readings were taken by means of the direct-current procedure in which the

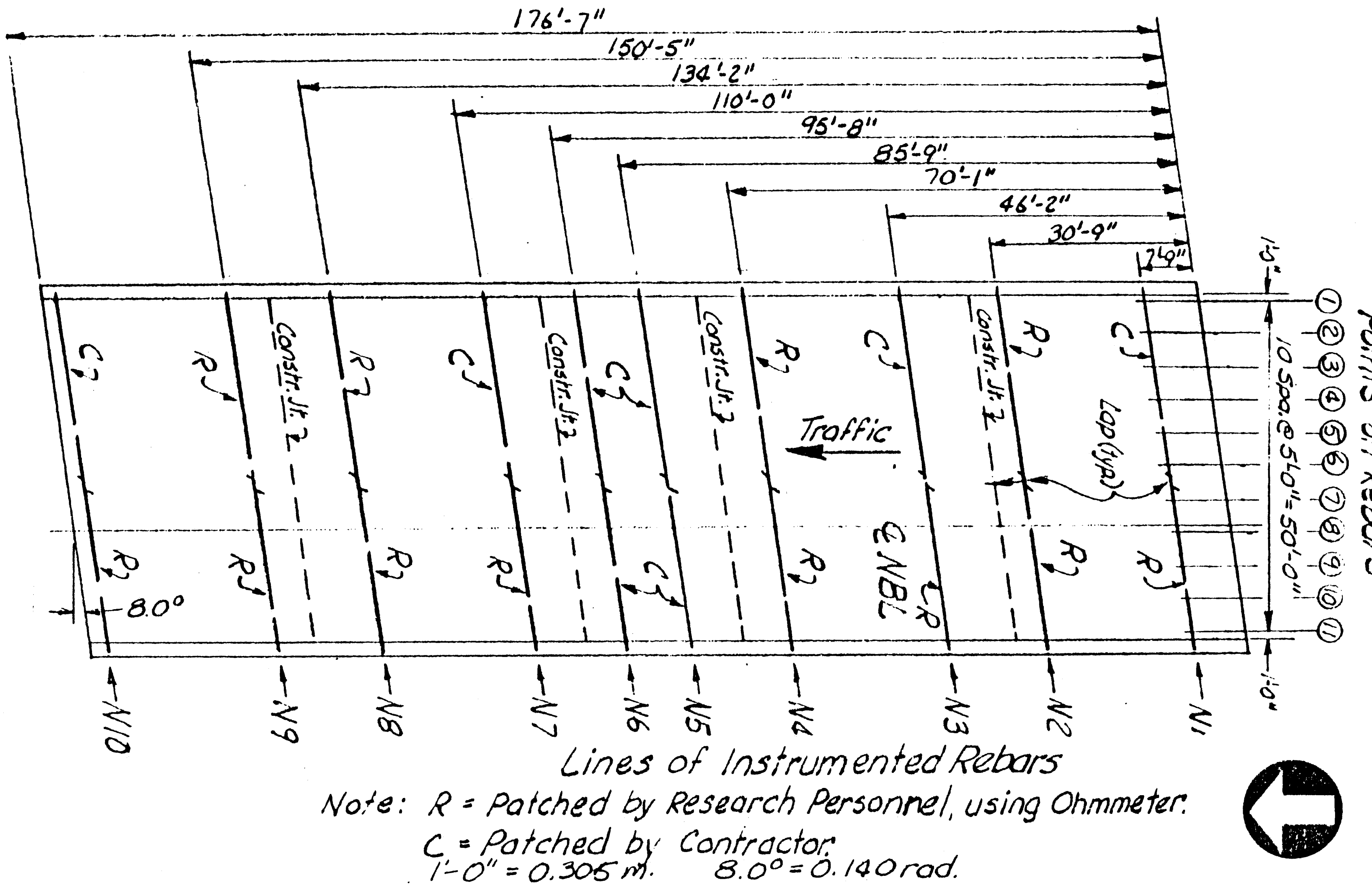

Figure 3. Location and degree of preparation, instrumented bars in NBL. Test grid is indicated.

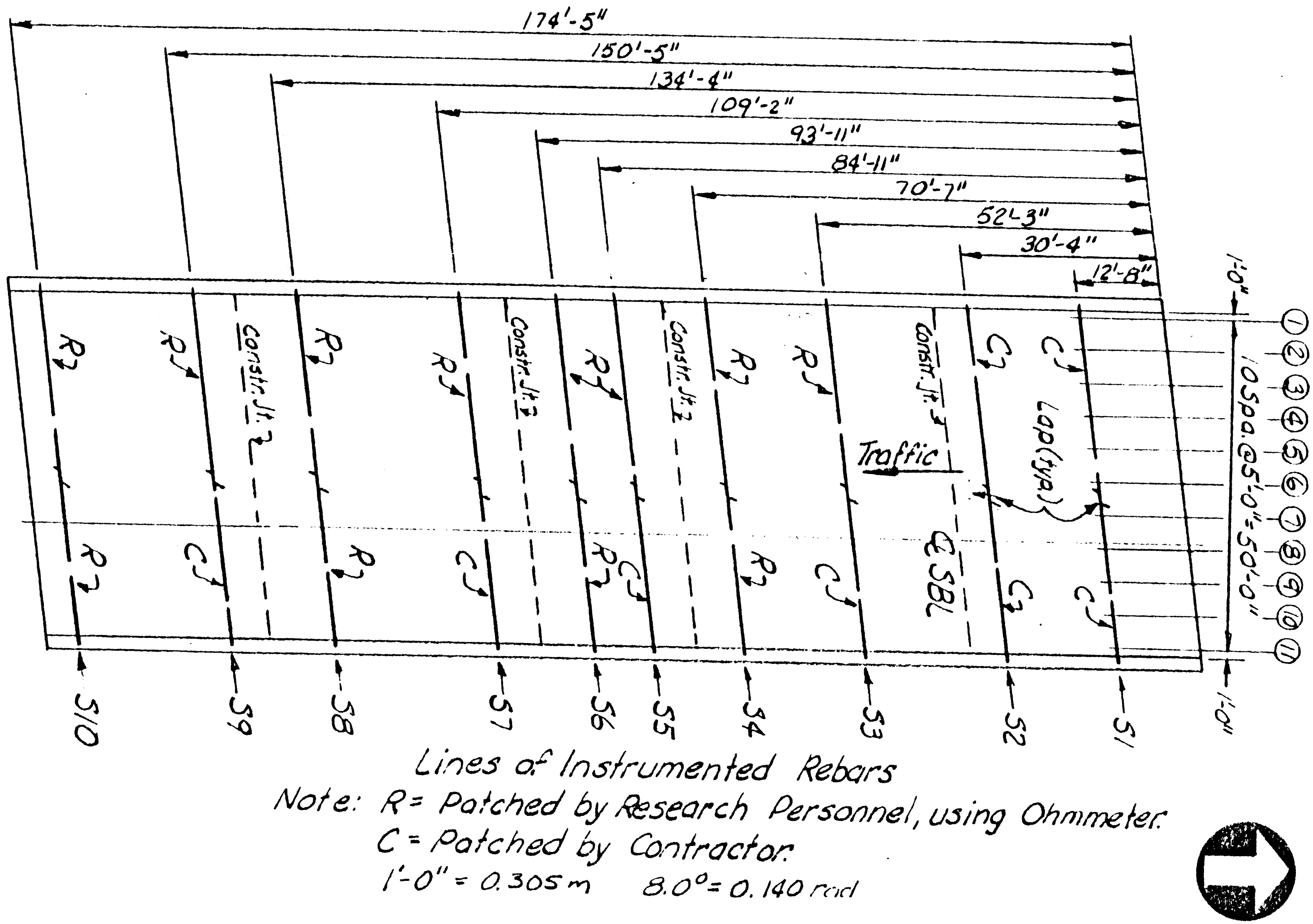

Figure 4. Location and degree of preparation, instrumented bars in SBL. Test grid is indicated.

Table 1

Resisvity Readings

Rte. I-77 (NBL) Bridge Over Rte. 620
(Values in ohms x 10^{-3})

Line (From Fig. 3)	Point 1	2	3	4	5	6	7	8	9	10	11
N1	4	6	1	2	2	1	1	1	1	2	3
N2	1	2	1	4	2	2	3	2	2	5	5
N3	2	4	1	1	1	1	2	3	3	2	3
N4	6	10	3	6	5	1	1	2	1	2	2
N5	2	2	4	2	2	1	1	1	1	1	1
N6	2	2	2	2	1	1	1	2	2	6	2
N7	14	12	6	5	1	2	4	6	4	9	10
N8	4	13	10	8	13	5	5	5	10	9	4
N9	2	14	4	2	2	3	5	6	3	3	6
N10	6	6	6	6	4	4	2	3	2	1	5

NOTE: Bars lap between points 6 & 7.

Table 2

Resistivity Readings

Rte. I-77 (SBL) Bridge Over Rte. 620
(Values in ohms x 10^{-3})

Line (From Fig.4)	Point 1	2	3	4	5	6	7	8	9	10	11
S1	8	6	1	2	1	2	2	2	2	2	2
S2	4	3	4	3	3	4	2	6	4	3	3
S3	4	2	3	2	2	2	2	1	1	1	1
S4	4	4	2	3	2	1	2	1	1	1	1
S5	12	3	3	5	3	1	1	2	4	4	3
S6	4	2	2	2	1	2	3	2	10	5	6
S7	6	3	3	2	2	2	2	2	2	2	2
S8	5	1	3	1	1	2	2	4	3	3	3
S9	17	3	2	10	4	1	2	2	2	4	4
S10	15	3	1	3	3	4	2	3	4	3	5

NOTE: Bars lap between points 6 & 7.

resistance is measured in a circuit between the steel, an ohmmeter with a 20,000 ohms per volt rating, and a 12" by 12" (0.09 m by 0.09 m) copper plate commonly used for the evaluation of waterproof membranes. The FHWA has questioned the suitability of this procedure, suggesting that an alternating-current technique yields more meaningful results.(1) Such equipment was not available at the Council, and it was felt that the direct-current procedure described earlier would be adequate to provide an indication of any damage to the coatings during concrete placement.

After placement of the concrete the readings shown in Tables 1 and 2 were obtained. These values, which are generally less than 10,000 ohms, are of the magnitude normally measured on bare concrete over uncoated steel, and they indicate that the epoxy coating is not intact. The low readings are believed to be due to ineffective sealing of the many flaws in the coating rather than to construction damage. While it is impossible to say with certainty that there was no damage during placement of the concrete, visual inspection by uncovering bars at various points disclosed no distress. There is no apparent difference between the readings for the bars coated by research personnel using the ohmmeter and those for the bars coated by contractor personnel in patching only the visible flaws. It is believed that all of the small holidays were not sealed. This conclusion seems reasonable, because some of the patching was done during cold weather and time did not permit rechecking the bars with the ohmmeter after patching.

ELECTRICAL POTENTIAL MEASUREMENTS

Electrical potential readings were also taken at 5' (1.5 m) intervals along the instrumented bars using the standard high impedance voltmeter and copper-copper sulfate half-cell equipment. The readings shown in Tables 3 and 4 for the northbound and southbound bridges, respectively, show no indication of corrosion as they are below the threshold value of 0.30 volt. No indication of corrosion was expected in these initial readings, but they will serve as a basis for comparison with future values that should indicate the initiation of active corrosion.

Earlier correspondence from the FHWA warns that potential readings will not measure the effectivenss of the epoxy coating, as the active corrosion indicated may be confined to a minute holiday.(1) However, the future potential readings will be used only as a guide to the presence of corrosion, and will be supplemented by data from chloride determinations, soundings, and comparisons with the performance of the control decks described earlier. The use of potential measurements in this manner is acceptable.(2)

Table 3

Electrical Potential Readings

Rte. I-77 (NBL) Bridge Over Rte. 620
(Values in volts, negative to the copper-copper sulfate half-cell)

Line (From Fig. 3)	Point										
	1	2	3	4	5	6	7	8	9	10	11
N1	0.12	0.07	0.05	0.04	0.07	0.05	0.06	0.09	0.06	0.05	0.05
N2	0.07	0.10	0.11	0.09	0.04	0.15	0.05	0.20	0.19	0.20	0.18
N3	0.08	0.03	0.04	0.03	0.06	0.00	0.19	0.19	0.13	0.05	0.16
N4	0.10	0.11	0.10	0.12	0.10	0.03	0.04	0.05	0.00	0.04	0.07
N5	0.11	0.09	0.10	0.11	0.10	0.08	0.00	0.07	0.01	0.05	0.05
N6	0.06	0.02	0.04	0.06	0.03	0.02	0.03	0.05	0.04	0.05	0.02
N7	0.08	0.06	0.04	0.05	0.00	0.10	0.15	0.17	0.17	0.15	0.15
N8	0.19	0.12	0.13	0.15	0.10	0.18	0.16	0.23	0.20	0.20	0.24
N9	0.05	0.07	0.05	0.06	0.03	0.26	0.26	0.26	0.26	0.26	0.25
N10	0.03	0.04	0.04	0.04	0.02	0.05	0.00	0.05	0.05	0.00	0.03

NOTE: Bars lap between points 6 & 7.

Table 4

Electrical Potential Readings

Rte. I-77 (SBL) Bridge Over Rte. 620
(Values in volts, negative to the copper-copper sulfate half-cell)

Line (From Fig. 4)	Point										
	1	2	3	4	5	6	7	8	9	10	11
S1	0.06	0.07	0.04	0.02	0.04	0.05	0.05	0.06	0.03	0.04	0.05
S2	0.04	0.05	0.05	0.04	0.06	0.05	0.04	0.08	0.08	0.03	0.06
S3	0.20	0.20	0.20	0.22	0.20	0.20	0.19	0.21	0.15	0.15	0.14
S4	0.16	0.19	0.14	0.20	0.18	0.06	0.09	0.03	0.05	0.04	0.06
S5	0.08	0.09	0.04	0.05	0.07	0.05	0.08	0.09	0.12	0.06	0.05
S6	0.14	0.16	0.13	0.15	0.13	0.14	0.17	0.14	0.18	0.17	0.15
S7	0.07	0.10	0.08	0.08	0.05	0.09	0.21	0.23	0.20	0.20	0.17
S8	0.21	0.22	0.21	0.20	0.19	0.23	0.23	0.24	0.22	0.24	0.20
S9	0.12	0.10	0.08	0.06	0.08	0.06	0.20	0.19	0.23	0.22	0.20
S10	0.10	0.08	0.05	0.05	0.07	0.06	0.12	0.05	0.07	0.05	0.05

NOTE: Bars lap between points 6 & 7.

DECK THICKNESS

Deck thickness measurements, such as the values shown in Figures 5 and 6 for the experimental bridges, are routinely obtained by probing during construction. As shown on these figures, the total deck thicknesses ranged from 8-1/2" to 9" (0.216 to 0.229 m) for both structures, with average values of 8.69" (0.221 m) in the northbound lane and 8.82" (0.224 m) in the southbound lane. These data reflect the current policy of the Department, which will pay for up to 1/2" (0.013 m) more thickness of deck concrete than is called for on the plans to assure adequate cover over the reinforcing steel. In the case of the experimental bridges a deck thickness of 8-1/2" (0.216 m) and a cover of 2-1/4" (0.057 m) to the center of the top steel were specified. If it is assumed that the extra depth of concrete represents additional cover, the cover depths become 2.44" (0.062 m) for the northbound and 2.57" (0.065 m) for the southbound lane. These values were verified by pachometer readings at several randomly selected sites.

CHLORIDE DETERMINATIONS

Part of the evaluation of the effectiveness of the coated reinforcement involves determinations of the chloride content of samples taken from the concrete deck and analyzed in accordance with procedures suggested by the FHWA.[3] Samples were taken from three points on each of the experimental bridge decks and three points on each of the two control decks on the Interstate 77 bridge over Rte. 775 soon after construction to provide a basis for the interpretation of later data. The values, shown in Table 5, range from 0.012 to 0.025 percent by weight. These values are in line with those from a study in which Tyson found the average amount of chlorides bound within several aggregates in Virginia to be 0.7 lb./yd.^{3} (0.43 kg/m^3).[4] Tyson's work indicated that the chlorides in the aggregate were incapable of contributing to the corrosion process, but they were measured in the titration method used in the chloride determinations. The base level of naturally occurring chlorides will be taken into account in future evaluations.

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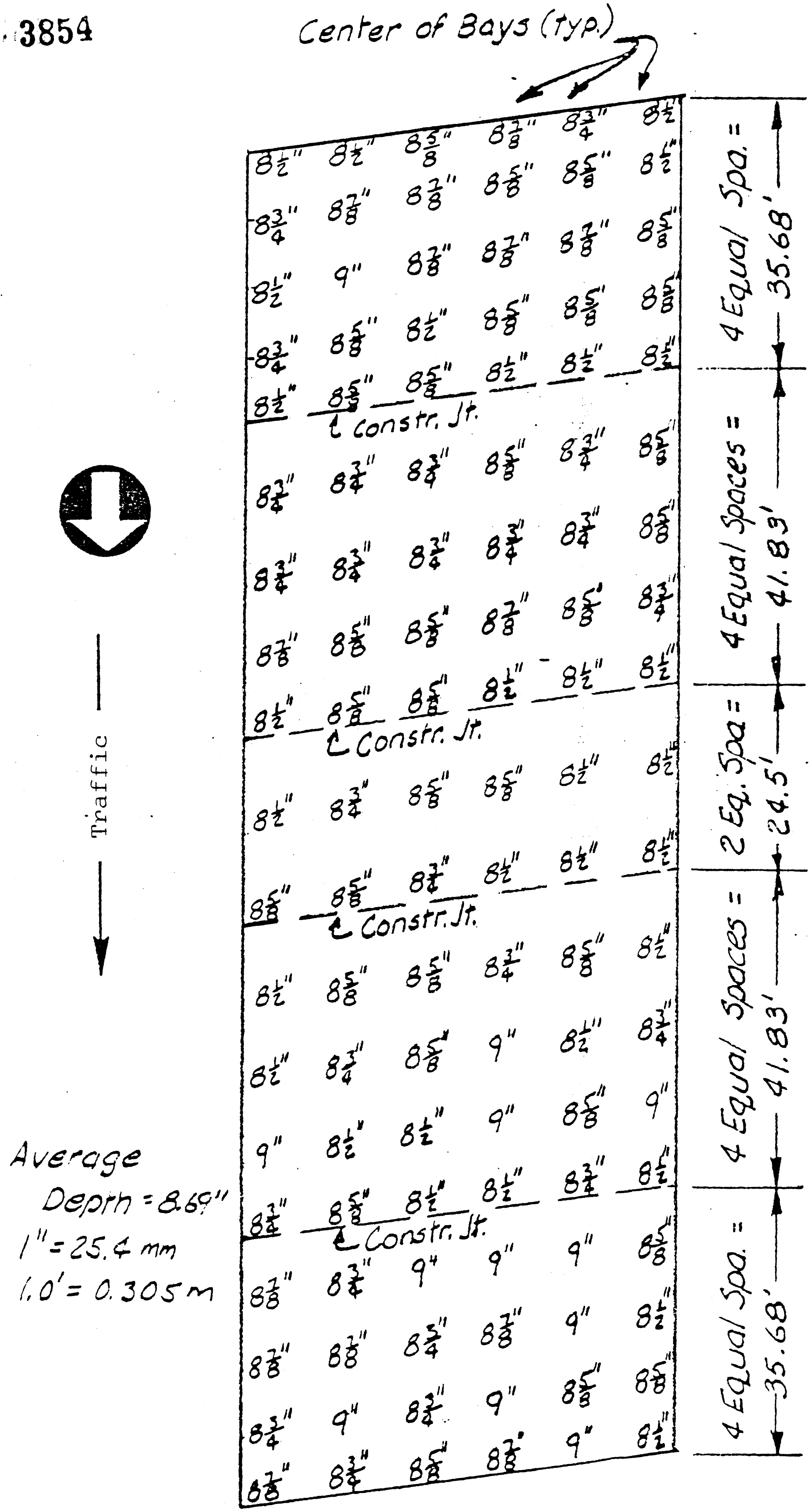

Figure 5. Depth of concrete deck, probes by inspectors, NBL bridge.

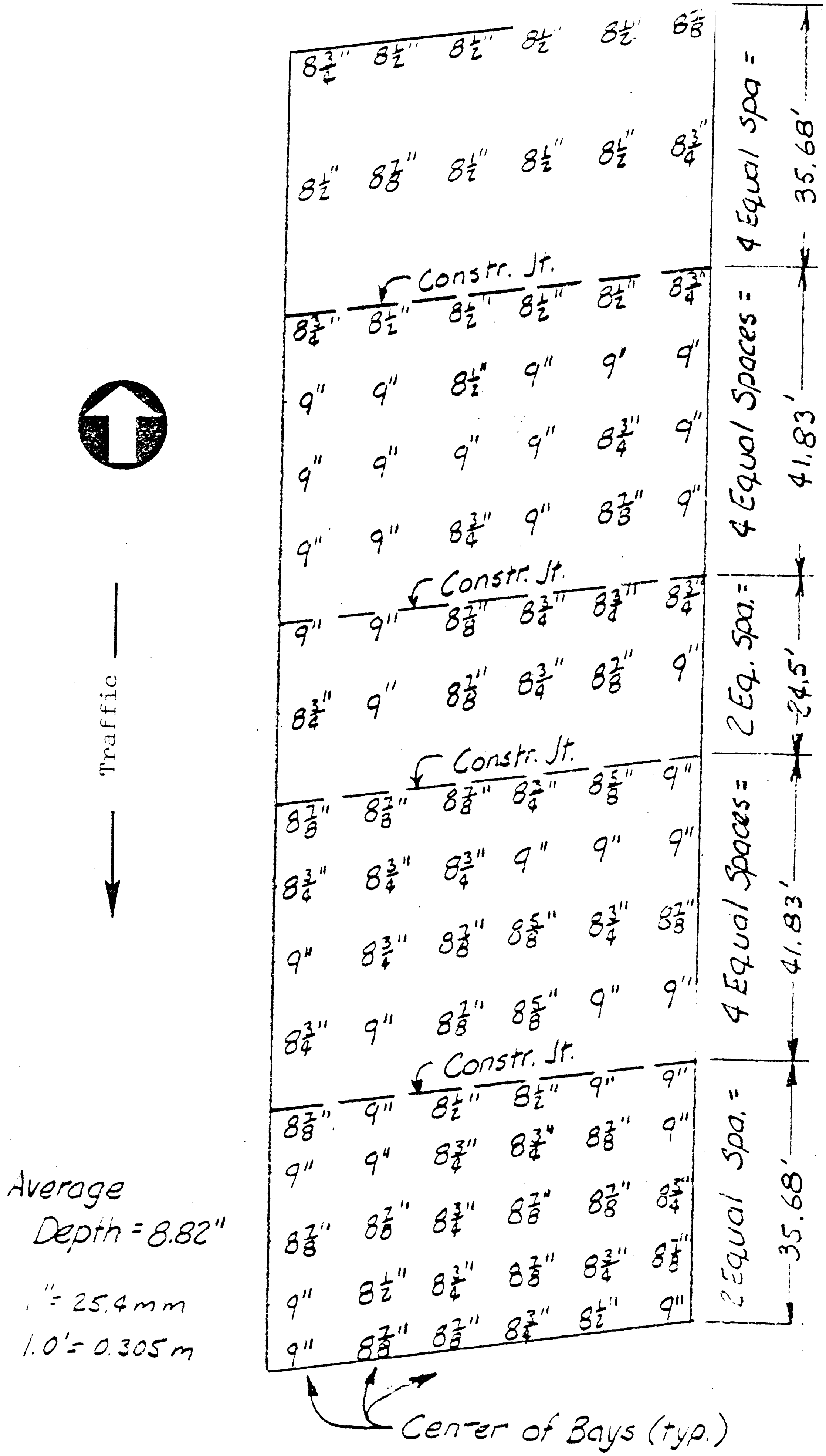

Figure 6. Depth of concrete deck, probes by inspectors, SBL bridge.

TABLE 5

RESULTS OF CHLORIDE ANALYSES

	Bridge	% Cl^-	lb./yd.^{3}
Experimental Bridges	B605— I-77 (NBL)/620	0.016 0.014 0.015	0.62 0.55 0.58
Experimental Bridges	B606— I-77 (SBL)/620	0.025 0.020 0.015	0.98 0.78 0.58
Control Bridges	B615— I-77 (NBL)/775	0.017 0.013 0.023	0.66 0.51 0.90
Control Bridges	B616— I-77 (SBL)/775	0.012 0.017 0.014	0.47 0.66 0.55

NOTE: Percentage chloride is by weight, averaged from duplicate analyses on each sample. Pounds per cubic yard are based on a weight of 3,900 lb./yd.^{3} ($\mp$ 145 lb.ft. or 2340 kg/m^3) for concrete. Analysis performed by J. W. Reynolds, Chemist, Virginia Highway and Transportation Research Council.

1 lb./yd.^{3} = 0.6 kg/m^3

OBSERVATIONS DURING CONSTRUCTION

Based on observations at the bridge site, the durability of the epoxy coated reinforcement was impressive. Reasonable care was taken to avoid damage to the coating in that the reinforcing bars were carefully bundled for shipment, the bundles were wrapped at the lift points when lifted at the site, and the bars were carried rather than dragged to their final position in the deck. There was no evidence of any significant damage to the steel during shipping or placement. The resistivity readings failed to provide any indication of damage during placement of the concrete because of ineffective patching, but no damage was apparent when the concrete was scraped away from the bars. No special precautions were taken during deck placement.

Portions of the coating appeared to have been rubbed away before curing. The edges of these exposed areas, generally on the edges of the bar deformations, were smoothly tapered rather than sharp or ragged as might be caused by cutting or abrading the cured epoxy. Because of the bare areas, the contractor was required to perform more than normal patching of the coating to satisfy the Department's inspectors.

In spite of the fact that this was the first experience of the contractor, Wilson Construction Company of Salisbury, North Carolina, with epoxy coated reinforcement, little delay was noted. Some inconvenience was noted, at least initially, due to the tendency of the coated bars to slide, or creep, more easily than normal steel during placement. The patching operation was not extremely time-consuming. Overall, the contractor's superintendent and other personnel seemed favorably inclined toward the coated reinforcement.

Several suggestions, such as eliminating the coated chairs and ties and reducing the amount of patching required, were made by contractor personnel based on their experience, and many of these requirements have been dropped from later editions of the specifications.[5]

COST DATA

The epoxy coated reinforcing steel on the Route 620 bridges was bid at \$0.75 per pound (\$1.72/kg) in-place, which represents a premium of \$0.35 per pound (\$0.80/kg) over the uncoated steel, which as bid at \$0.40 per pound (\$0.92/kg), also in-place. The cost of the 69,277 lb. (31,424/kg) of coating per bridge is \$24,246.95, or \$2.60/ft.^{2} (\$27.99/m^2) of clear roadway area. Currently, the premium paid for coated reinforcement is about \$0.25/lb. (\$0.57/kg), which equates to \$1.86/ft.^{2} (\$20.02/m^2). A further reduction would occur, of course, if only the top mat of steel were coated.

CONCLUSIONS

Although a complete evaluation of the effectiveness of the coated reinforcement cannot be made until the decks have been exposed to deicing salt, some conclusions can be drawn regarding the construction operations.

1. Given the reasonable care exercised by the applicator and contractor in shipping and handling the bars, no damage occurred in moving the bars from the plant to their final position in the deck.

2. Use of the liquid epoxy patching compound supplied with the coated steel proved ineffective in correcting widespread defects in the coating, even when the ohmmeter was used to define the faulty areas. It is important that the purchasing agency specifications be enforced while the coated reinforcement is at the applicator's plant.

3. While the resistivity values were not definitive, a limited number of observations showed no visually apparent damage to the coated bars during placement of the concrete.

4. The reaction of the contractor after his first experience with coated reinforcement was quite favorable. Beyond the handling requirements, the contractor's main problem appeared to be a tendency for the smooth surfaced steel to slip, or creep, during placement in the forms. The patching requirements were questioned, but these have been relaxed in later revisions of the special provisions.

5. With the method utilized, electrical connections to the coated reinforcement were easily made. It is suggested that the wiring scheme shown in Figure 2 be employed whenever electrical potential or resistivity readings are anticipated, whether the reinforcing steel is coated or bare. Installation of the wiring at the time of construction will eliminate the need to drill into the deck to provide the necessary direct connection.

FUTURE EVALUATIONS

The ultimate test of epoxy coated reinforcing steel is the protection that it offers against the deleterious effects of deicing salts. It would be of special interest to continue the evaluation of the test bridges, because of the indications that the epoxy coating was not intact.

Continuing evaluations would involve deck surveys, including soundings, potential measurements over the instrumented bars, and chloride content determinations on an annual basis for the experimental and control structures. Base chloride data have been obtained, and it now appears that both sets of bridges will be opened by the fall of 1977.

It is strongly recommended that the evaluations be continued and be reported annually by memorandum for a period of five years, unless a definitive comparison of deck performance can be made earlier.

ACKNOWLEDGEMENTS

The first use of epoxy coated reinforcing steel in Virginia, with its attendant field evaluation, required the cooperation and active participation of many people within the Department of Highways and Transportation. The author gratefully acknowledges the efforts of Messrs. F. G. Sutherland, F. L. Burroughs, J. E. Galloway, Jr., J. G. G. McGee, and E. J. Gillikin of the Central Office and Messrs. M. E. Wood, Jr., D. V. Cranford, and R. M. Strauser of the Salem Construction District.

In particular, the successful completion of the work depended greatly on the efforts of people under Mr. Strauser at the Hillsville Residency, including Messrs. R. G. Stoots, project engineer, J. H. Stout, Jr., project inspector, and R. C. Cressenberg, and R. L. Taylor, inspectors. The residency personnel provided the wealth of information required to coordinate a study at a site distant from the research offices and helped in patching the bars and recording their placement in the deck. Their unfailing cooperation is greatly appreciated.

Also essential to the success of the project was the great cooperation provided by personnel of the Wilson Construction Co. of Salisbury, North Carolina, particularly Messrs. Bill Carter and George Icard.

The responsibility for much of the coordination, field work and data gathering in this project fell to James W. French, materials technician at the Research Council. Without his reliable assistance the work could not have been completed.

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4. Tyson, S. S., "Two-Course Bonded Concrete Bridge Deck Construction— Interim Report No. 2, Concrete Properties and Deck Condition Prior to Opening to Traffic", Virginia Highway and Transportation Research Council, Charlottesville, Virginia, July 1976.

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APPENDIX

SPECIAL PROVISION FOR EPOXY COATED REINFORCING STEEL

DESCRIPTION - This work shall include furnishing and placing epoxy coated reinforçing steel in the bridge decks (excluding reinforcing steel in parapet walls) on this project and the provisions of Section 406 shall apply except as modified herein.

MATERIAL - Reinforcing steel shall conform to Section 228(a)1 of the Specifications.

The coating material shall be one of the following powdered epoxy resins:

1. MICCRON 650 - manufactured by Republic Steel.

2. SCOTCHKOTE 202 - manufactured by Minnesota Mining and Manufacturing Company.

3. LSU 431 Formula 907-2-5 - manufactured by Ciba-Geigy Corporation.

4. FLINTFLEX 531-6020 - manufactured by E. I. DuPont deNemours Company, Inc.

The powdered resin shall conform to the specification of the manufacturer and shall be of the same material and quality submitted to the National Bureau of Standards for evaluation and test. Information on the epoxy resin that is considered by the resin manufacturer to be essential to the proper use and performance of the resin as a coating shall be supplied to the Department. A written certification stating that the material furnished for the coating of the reinforcing steel is the same formulation as that previously submitted to the National Bureau of Standards for evaluation as identified herein, shall be signed by a responsible officer of the resin manufacturing company and submitted to the Department. A representative sample of 8 oz. of the resin powder used to coat each given lot of bars shall be packaged in an air tight container with identification by lot number and submitted to the Department.

REINFORCING STEEL SURFACE PREPARATION - The surface of the bars to be coated shall be clean and free from rust, scale, oil, grease, and similar surface contaminants. The surface shall be cleaned to white metal in accordance with the Steel Structure Painting Council Surface Preparation Specification SSPG-SP5-63T amended Janaury 1, 1971. All traces of grit, dust, or other material from the cleaning shall be removed prior to coating. The coating shall be applied to the cleaned surface as soon as possible after cleaning and before visible oxidation of the surface occurs.

COATING APPLICATION - The coating shall be applied to the hot or cold reinforcing steel as an electrostatically charged dry powder sprayed onto the grounded steel bar using an eletrostatic spray gun.

The coating shall be applied as a uniform, smooth coat having a film thickness after curing of 7 mils ∓ 2 mils. Thickness of the film shall be measured on a representative number of bars from each production lot by the same method outlined in ASTM G12-69T for measurement of film thickness of pipeline coatings on steel.

The coated bars shall be given a thermal treatment specified by the manufacturer of the epoxy resin which will provide a fully cured finished coating. A representative proportion of each production lot shall be checked by the method found by the coating applicator to be the most effective for measuring cure to insure that that the production lot of coating is supplied in the fully cured condition.

The coating shall be checked after cure for continuity of coating and shall be free from holes, voids, contamination, cracks, and damaged areas. There shall not be more than two holidays (pinholes not visually discernible) in any linear foot of the coated bar. A holiday detector shall be used in accordance with the manufacturer's instructions to check the coating for holidays. A 67½ volts detector such as the Tinker and Rasor Model M-1 or its equivalent shall be used.

The flexibility of the coating shall be evaluated on a representative number of bars selected from each production lot. A No. 6 bar shall be capable of being bent 120 degrees over a mandrel of 3-inch radius without visible evidence of cracking of the coating. The bending test shall be conducted at room temperature (68^o to 85^o) after the specimen has been exposed to room temperature for a sufficient time to insure that it has reached thermal equilibrum.

Four 4 in. x 4 in. x .05 in. (18 gage) steel panels shall be coated with a 7 mil ∓ 2 mil coating by the same method and with the same lot of resin used on the bars. The panels shall be tested to determine the resistance of the coating to abrasion by a Taber abraser or its equivalent using CS-10 wheels and a 1,000 gram load per wheel. Resistance of the coating when so tested shall be such that the weight loss shall not exceed 100 mg. per 1,000 cycles.

INSPECTION - A Certificate of Compliance for each shipment of coated bars shall be furnished to the Department. The Certificate shall state that representative samples of the coated bars have been tested and that the test results conform to the requirements outlined herein. Test reports shall be retained and made availalbe as provided in Section 9.1 of AASHO M218.

The Department shall have free access to the coating applicator's plant for inspection and shall have the right to require that preparation, coating, and curing of the bars take place in the inspector's presence. Random samples of lengths of coated bars may be taken by the Department at the point of coating application for the purpose of evaluation or tests.

FABRICATING, SHIPPING, AND HANDLING OF EPOXY COATED STEEL - excelsior or equivalent padded metal bands shall be used for bundling the coated bars for shipment. Caution shall be used in fabricating, loading, and unloading bars to prevent damage to the coating. Bars whose coatings are severely damanged shall be replaced or returned to the fabricator for shop repair.

Minor damaged areas of coated bars and sheared or cut ends of bars shall be repaired or patched by the use of patching material supplied by the epoxy resin manufacturer. The patching material shall be compatible with the coating, inert in concrete, and capable of being applied in the field. Repairs shall be made as soon as practical, and patching of sheared or cut ends shall be performed prior to visible oxidation of the surface.

PLACING AND FASTENING - Epoxy coated reinforcing steel shall be supported in the bridge deck on plastic, plastic coated, or other approved wire supports and held in place by the use of plastic coated or other approved wires or molded plastic clips especially fabricated for this purpose.

Following placement of deck reinforcement and prior to placing concrete, inspection of the reinforcement will be made and minor damaged areas shall be repaired as specified herein.

METHOD OF MEASUREMENT - Epoxy coated reinforcing steel will be measured in units of pounds of uncoated steel, and the weight will be computed from the theoretical weights of the nominal sizes of steel specified and actually placed in the structure. Measurement will not be made of the coating material.

BASIS OF PAYMENT - Epoxy coated reinforcing steel will be paid for at the contract unit price per pound, which price shall include furnishing the steel and epoxy coating material, applying the coating material, fabricating and placing epoxy coated reinforcement in the structure.

Payment will be made under:

Pay Item	Pay Unit
Epoxy Coated Reinforcing Steel	Pound

SOURCE OF INFORMATION - Information on epoxy coatings and Applicators capable of applying the coatings may be obtained by contacting any of the following:

1. Republic Steel Corporation
   Miccron 650 - Blue Epoxy

   Contact: William J. Cummins
   Market Development Division
   Republic Steel Corporation
   Cleveland, Ohio 44101
   Telephone - 216-574-7153

2. Minnesota Mining and Manufacturing Company
Scotchkote 202

Contact: Richard W. Saltzman
Protective Products Division
887 Woodcress Drive
Dover, Delaware 19901
Telephone: 302-678-2861

3. Ciba-Geigy Corporation
Ciba-Geigy - LSU 431 - Formula 907-2-5

Contact: Ken E. Dempsky
Ciba-Geigy Corporation
Resins Department
Saw Mill River Road
Ardsley, New York 10502
Telephone: 914-478-3131

4. E. I. DuPont de Nemours Company, Inc.
Dupon - Flintflex 531-6020

Contact: Philip L. Krug, National Manager
New Construction and Maintenance Finishes Sales
E. I. DuPont de Nemours Company, Inc.
308 East Lancaster Avenue
Wynnewood, Pennsylvania 19096
Telephone: 215-878-2700

Alternate Contact:
Fabric and Finishes Department
E. I. DuPont de Nemours & Company, Inc.
Wilmington, Deleware 19898
Telephone: 302-774-6395