FINAL REPORT

EVALUATION OF EPOXY-COATED REINFORCING STEEL

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Virginia Department of Transportation
VDOT
Research Council

VIRGINIA TRANSPORTATION RESEARCH COUNCIL

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/VA-94-R5		

4. Title and Subtitle	5. Report Date
Evaluation of Epoxy-Coated Reinforcing Steel	July 1993
	6. Performing Organization Code HPR #79
7. Author(s) Wallace T. McKeel, Jr.	8. Performing Organization Report No. VTRC 94-R5
9. Performing Organization Name and Address Virginia Transportation Research Council Box 3817, University Station Charlottesville, Virginia 22903-0817	10. Work Unit No. (TRAIS) HPR #79
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address Virginia Department of Transportation 1401 E. Broad Street Richmond, Virginia 23219	13. Type of Report and Period Covered Final Report 7/8/75-6/30/90
	14. Sponsoring Agency Code

15. Supplementary Notes

None

16. Abstract

Virginia's first installation of epoxy-coated reinforcing steel, which was opened to traffic in 1977, was evaluated during construction and through 13 years of service. It was apparent at the time of construction that the integrity of the coating application did not meet the requirements of the specifications There were many flaws and holidays in the coatings on all of the bars, and patching with a liquid epoxy compound was not effective. Although the applicability of the findings, which are based on an application that does not represent the best practice, may be limited, useful information on the durability of the coated steel and its role in protecting the deck was developed.

It was found that the coated reinforcement was exposed to relatively high chloride concentrations at transverse cracks in the decks early in the life of the structures, but the decks remained in good condition throughout the evaluation period. It was concluded that despite the poor coatings, the coated reinforcing steel contributed to the deck's durability by providing enhanced protection at critical cracked sections. Rebars taken from deck cores showed no signs of rusting, although the steel had a dull dark gray finish that may be underfilm corrosion. No debonding of the coating was evident.

17. Key Words	18. Distribution Statement
bridge decks, bridge deck deterioration, deck cracking, reinforcing steel, epoxy-coated reinforcing steel, corrosion of reinforcing steel, bridge deck protective systems	No restrictions. This document is available to the public through NTIS, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	16	

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

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

December 1993
VTRC 94-R5

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ABSTRACT

Virginia's first installation of epoxy-coated reinforcing steel, which was opened to traffic in 1977, was evaluated during construction and through 13 years of service. It was apparent at the time of construction that the integrity of the coating application did not meet the requirements of the specifications There were many flaws and holidays in the coatings on all of the bars, and patching with a liquid epoxy compound was not effective. Although the applicability of the findings, which are based on an application that does not represent the best practice, may be limited, useful information on the durability of the coated steel and its role in protecting the deck was developed.

It was found that the coated reinforcement was exposed to relatively high chloride concentrations at transverse cracks in the decks early in the life of the structures, but the decks remained in good condition throughout the evaluation period. It was concluded that despite the poor coatings, the coated reinforcing steel contributed to the deck's durability by providing enhanced protection at critical cracked sections. Rebars taken from deck cores showed no signs of rusting, although the steel had a dull dark gray finish that may be underfilm corrosion. No debonding of the coating was evident.

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INTRODUCTION

Deterioration of concrete bridge decks emerged as a major national maintenance concern in the late 1950s according to a synthesis published by the National Highway Research Program.[1] A cooperative study by the Bureau of Public Roads, 10 state highway departments, and the Portland Cement Association in 1962 documented the problem, although its true extent and urgency were yet to be realized.[2] The spalling of decks and the dislodging of the concrete over the reinforcing bars as a result of pressures exerted within the deck as the steel corroded has since been recognized as the most serious form of deck deterioration.[3] Corrosion occurs when the normally passive state of the steel in the concrete is altered by the presence of chloride ions from deicing salts that have permeated the concrete. Among the steps taken by the bridge engineering community to combat corrosion by eliminating or delaying the penetration of the chloride ions were (1) designing more impermeable concrete mixes, (2) increasing the depth of the concrete cover over the steel, and (3) placing waterproof membranes on the surfaces of decks. One promising approach was coating the bars with a thin layer (7-mm) of an appropriate 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 for bending of the bar and to withstand the abuse of normal construction handling.[4]

Satisfied with the laboratory performance of the coated steel, the FHWA encouraged its use and evaluation in field installations, one of which (Virginia's initial installation of the product) is the subject of this report. This and other studies supported the refinement of materials and application specifications to improve the product's performance, and in the last 15 years, epoxy-coated reinforcing steel became the protective system of choice in Virginia and many other states.

Recently, however, some agencies, notably the Florida Department of Transportation, have reported severe difficulties with certain types of installations of epoxy-coated reinforcing steel.[5] Research by a firm of consulting corrosion specialists[6] stated that "epoxy coated rebar technology is flawed" and

concluded that the system "can no longer be considered a viable primary protective system for North American bridge structures in corrosive environments with expected maintenance-free lives in excess of about 15 years in northern environments or more than 5 years in hot, salty and moist southern exposures." The consultant recommended against the continued use of epoxy-coated reinforcing steel as the primary protection in adverse environments for structures for which low-maintenance lives in excess of these limits is desired. Other agencies, notably the FHWA, have questioned the harshness of these conclusions and recommendations. A recent memorandum[7] on the subject describes additional research to provide a complete evaluation of the corrosion and failure mechanisms of epoxy-coated reinforcing steel. The memorandum notes that "The current policy of the FHWA is to continue to support the use of ECR as an alternative cost-effective means of combating corrosion in bridge decks."

This report describes the results of evaluations of the construction and early performance of the Virginia Department of Transportation's first use of epoxy-coated reinforcing steel in bridge decks. The test structures were the two bridges carrying the northbound and southbound lanes of Interstate 77 over Route 620 in Carroll County, Virginia. Each bridge is a three-span, continuous steel beam structure with spans of 53, 73.5, and 53 ft. All of the transverse and longitudinal bars in the top and bottom reinforcing mats of the decks, a total of 138,554 lb., was epoxy coated at a cost of $0.75/lb. Only the deck reinforcement was coated; epoxy-coated reinforcement (ECR) was not commonly used in substructures in Virginia until after 1985. In 1985, the Department began using ECR in pier caps at deck joint locations, and in 1990, the use was extended to abutment seats and backwalls at joint locations.

An earlier report covered the evaluations of the coated steel during construction operations.[8] Subsequent evaluations were conducted annually until 1981 as part of the original research effort. At the request of the FHWA, the evaluation was then extended until 1990, and a 3-year inspection cycle was adopted. All of the information collected during the first 13 years of service (1977-1990), which is the formal research period, is summarized in this report. A visual inspection of the decks in 1993 disclosed no apparent changes in the condition of the bridges.

PURPOSE AND SCOPE

The purpose of this study was to evaluate the effectiveness of Virginia's first installation of ECR as a bridge deck protective system. Information on problems encountered during the coating of the steel and its durability during construction operations and under service conditions were also developed. Such information guided refinements in acceptance and handling procedures as the usage of ECR increased.

The study was limited to evaluations of the ECR in the decks of the two bridges in Carroll County and two nearby control bridges constructed with uncoated steel. The control bridges, which carry I77 over Routes 148 and 775, were the closest structures on the main line of Route 77. Unfortunately, the control bridges, although exposed to similar climatic conditions and chloride application rates, differed from the control structures in design. Reinforced concrete T-beam bridges, such as the control bridges, can be expected to exhibit different deterioration rates from the more flexible continuous span test bridges. The evaluations included observation of operations during construction of the bridges and field evaluations of the decks for a period of 13 years after they were opened to traffic.

METHODS

The initial evaluations consisted of detailed observations during all phases of the shipping, storage, handling, and placement of the steel and concrete. Personnel from the state and contractor also provided information used in the evaluation.

During construction, 10 coated bars on each of the 2 test bridges were fitted with wires that ran through the concrete to the top of the parapets to facilitate resistivity readings (a measure of coating integrity) and half-cell potential measurements (an indication of active corrosion). Locations of the instrumented bars were recorded, and the initial resistivity, half-cell potential, chloride content, and deck thickness data were obtained.

Later evaluations included the following procedures:

- visually inspecting the decks of the test and control bridges, including the top and bottom surfaces
- sounding the decks with a chain drag to disclose any delaminated areas
- surveying the decks with a pachometer to locate and determine the depth of the reinforcing steel (as required)
- measuring half-cell potentials at points on the instrumented bars of the test decks and on the control decks to disclose any areas of active corrosion on the steel

- sampling the deck concrete at selected points and at various depths for subsequent laboratory determinations of chloride content.

The final (1990) evaluations included these procedures and, in addition, the following:

- measuring the three-electrode linear polarization (3LP) resistances to determine the rates of any active corrosion

- coring the decks to allow a visual inspection of the conditions of the epoxy coating and the underlying steel at selected points on the decks.

RESULTS

Observations During Construction

Visits were made to the site at frequent intervals during the construction of the test bridges, and most of the critical placement of the deck concrete was observed. Reasonable care was taken to avoid damage to the coated steel during the shipping and the placing of the steel in the deck forms, i.e., the bars were carefully bundled and were carried rather than dragged to their positions in the decks. No special precautions appeared necessary, or were taken, during deck placement. The durability of the coated reinforcement was impressive, and no construction-related damage was noted. Despite the fact that the bars were stored uncovered at the site for several months during construction, no adverse effects on the coatings were apparent.

It was noted, however, that the application of the epoxy coating did not meet the requirements of the special provisions for the product, which allowed no more than two holidays (pinholes not visually discernible) per foot of bar (see the Appendix). There were, in fact, numerous visually discernible flaws on most of the bars. Attempts were made by the researchers to repair the coatings on some of the instrumented bars with a compatible liquid epoxy system supplied by the applicator, and the contractor repaired some of the more obvious flaws once the steel was in place. Neither effort restored the coatings to the required state. Resistivity values obtained immediately after the curing of the deck concrete were of the magnitude normally measured on bare concrete over uncoated steel. No further restivity measurements were made during the remainder of the project.

Cover Depth Measurements

The plans for the test bridges called for a minimum deck thickness of 8.5 in. with a cover depth of 2.25 in. to the centers of the top reinforcing bars. At the time of construction, the Department's policy was to pay for up to 0.5 in. of additional thickness to ensure adequate cover over the steel. Probing during placement indicated deck thicknesses of 8.5 to 9 in. for both bridges, with average values of 8.69 in. in the northbound lane and 8.82 in. in the southbound lane. If it is assumed that the extra depth represents additional cover, as was intended, the cover would be 2.44 in. in the northbound and 2.57 in. in the southbound lane. Pachometer readings verified thicknesses of approximately 2.5 in. for the test bridges. Coring of the decks as part of the final field evaluation in 1990 indicated that the pachometer values may have been slightly low. Actual cover depths on the cores ranged from 2.75 to 2.88 in., averaging 2.75 in.

Pachometer surveys of the control decks indicated cover depths generally in the range of 2 to 2.75 in., although there was one area with as little as 0.5 in. of cover.

Visual Inspections and Soundings

Fine pattern and transverse cracking was noted in the test decks after only 2 years of service. The cracking, which is of the type found frequently on continuous span bridges, occurs in both the positive and negative moment areas of the structures and is not caused by corrosion.

The cracking has continued to progress in both severity and extent. After 7 years of service, two of the cracks in one area of the northbound bridge had propagated through the depth of the slab. This was indicated by efflorescence on the bottom surface. This situation has not worsened in the ensuing years, but all of the cracks have widened at their tops as a result of the bridges vibrating under load. A recent visual inspection (without soundings) disclosed cracking that might indicate an incipient joint spall.

The extent of the cracking depends on location. There is more cracking in the traffic lane than the passing or turning lanes, and it is more prevalent on the southbound bridge, which is located on a downgrade. Despite the widespread cracking, no delaminations have been disclosed by the deck soundings.

Only short, narrow cracks have been noted on the more rigid reinforced concrete beams of the control bridges. One small spall was noted in the area of shallow concrete cover after 10 years of service. The delaminated area has since increased in size, but it is localized in a single area. Cracking, soundings, and half-cell potential indicated the presence of an incipient joint spall in one of the bridges. The spall has increased in severity in the ensuing 6 years.

Corrosion Assessments

Half-cell potential measurements were conducted initially and during every subsequent evaluation through 13 years of service to determine the presence of active corrosion in the decks of both the test and control bridges. Readings were taken on a 5- by 5-ft. grid on the control decks and at 5-ft. intervals on the instrumented bars of the test decks.

Some values in the "uncertain" range (-.20 V. to -.35V. CSE) have been recorded during every evaluation since 1978, but there have been very few values indicative of active corrosion (more negative than -.35V. CSE). Those values have been found in the control spans at the joint spall and in the area of delaminated concrete resulting from shallow cover, described earlier, and at isolated points that are often near the joints in the simply supported slabs.

Only three points indicative of active corrosion have been recorded on the coated bars in the test decks. The number of points with values in the "uncertain" range has increased over time, however, particularly on the southbound bridge. Three-electrode linear polarization resistances obtained at the final evaluations in 1990 did not disclose any active corrosion in the test decks, and the chloride contents of the decks were high only in the transverse cracks.

Chloride Content Determinations

Chloride contents in this study were determined through the analysis of pulverized samples of concrete taken from 1.5-in. diameter holes drilled in the decks. The samples were taken over a .5-in. depth in the decks, i.e., the hole was drilled to a depth of 2 in., the drill removed and cleaned, and all residue removed. The depth was then increased to 2.5-in., and the pulverized sample collected for laboratory analysis. Wide variations in the values were common, but the data indicate the potential for corrosion at the sample depth. The corrosion threshold, the chloride content required to support active corrosion, is approximately 1.3 lb./yd.^{3}

Baseline chloride contents, indicative of those chlorides naturally occurring in the aggregates of the concrete, were obtained at the time of construction. The chlorides are tightly bound in the aggregates and do not react to enhance corrosion, but their contents are reflected in the test procedure used in this study. The baseline values, which average 0.65 lb./yd.^{3} for the decks in this study, seem high when compared to subsequent values, although they are in line with an earlier study[9] that indicated that several Virginia aggregates averaged 0.7 lb./yd.^{3} The effect of the bound chlorides should be considered, to some degree when evaluating the test results obtained from the field tests.

When reduced by the base values, the chloride contents after 7 years of service (1984) were inconsequential except for values taken at a transverse crack in the northbound test bridge. Chloride contents at that location were

over 2 lb./yd.^{3} at a depth of 1.75 to 2.25 in. in the slab. Subsequent data, obtained during 1987 (10 years) and 1990 (13 years) are shown in Tables 1 and 2. Sample depths shown in the tables are A = 1 to 1.5 in., B = 1.5 to 2 in., and C = 2 to 2.5 in.

Table 1
CHLORIDE CONTENTS TEST BRIDGE: I-77 OVER RTE. 620

Date	Sample No.	Location	Depth	Chloride lb./yd.^{3}
Northbound Bridge				
1987	1	Uncracked concrete	C	0.10
	2	Transverse crack	C	0.90
	3[a]	Transverse crack	C	3.29
1990	4-1	Uncracked concrete	A	0.62
	4-2	do.	B	0.47
	4-3	do.	C	0.40
	5-1	Uncracked concrete	A	3.16
	5-2	do.	B	2.14
	5-3	do.	C	1.22
	6-1	Uncracked concrete	A	3.38
	6-2	do.	B	2.16
	6-3	do.	C	1.20
	7-1	Transverse crack	A	3.01
	7-2	do.	B	2.34
	7-3	do.	C	2.08
	8-1	Transverse crack	A	2.63
	8-2	do.	B	2.68
	8-3	do.	C	2.55
Southbound Bridge				
1987	9	Uncracked concrete	C	0.42
	10	Uncracked concrete	C	0.75
	11	Transverse crack	C	2.98
1990	12-1	Uncracked concrete	A	1.00
	12-2	do.	B	0.60
	12-2	do.	C	0.56
	13-1	Uncracked concrete	A	0.92
	13-2	do.	B	0.47
	13-3	do.	C	0.42
	14-1	Transverse crack	A	2.63
	14-2	do.	B	2.77
	14-3	do.	C	2.59
	15-1	Transverse crack	A	3.09
	15-2	do.	B	2.85
	15-3	do.	C	2.23

a. Indicates values taken on crack that had penetrated full depth of slab.

Table 2
CHLORIDE CONTENTS CONTROL BRIDGES: I-77 OVER RTE. 148/775

Date	Sample No.	Location	Depth	Chloride lb./yd.^{3}
Northbound Bridge				
1987	1	Uncracked concrete, Span 1	C	0.32
	2	Uncracked concrete, Span 2	C	0.35
	3	Joint spall, Span 4	C	0.36
1990	4	Uncracked concrete, Span 1	C	0.61
	5	Uncracked concrete, Span 2	C	0.58
	6	Uncracked concrete, Span 3	C	0.71
	7	Uncracked concrete, Span 4	C	0.66
Southbound Bridge				
1987	8	Uncracked concrete, Span 2	C	0.44
	9	Uncracked concrete, Span 2	C	0.48
	10	Uncracked concrete, Span 4	C	0.31
1990	11	Uncracked concrete, Span 1	C	1.07
	12	Uncracked concrete, Span 2	C	0.54
	13	Uncracked concrete, Span 3	C	0.67
	14	Uncracked concrete, Span 4	C	1.19

Examination of Cores

Four cores were taken from the decks of the test bridges as part of the final (1990) evaluations, providing an opportunity to examine the condition of the reinforcing steel. The cores, three of which were taken over transverse cracks, were examined immediately after their removal from the decks. Those at cracked sections were heavily stained with material from the roadway surface, and they separated at the cracks, allowing ready access to the steel. There was no indication of rusting on any of the bars, but corrosion may have occurred beneath the epoxy film. Although the epoxy coatings remained tightly bonded to the steel in every case and could be removed only by scraping with a knife, the underlying steel had a dull, dark gray finish instead of the white metal required in the original special provisions (appended to this report). No evaluation of the surface condition was made at the time of construction, however, rendering a true comparison impossible. No further tests were conducted on the steel.

Coring also provided a limited opportunity to measure the actual cover depths. Values ranged from 2.5 to 3 in., with a mode of 2.75 in. These are slightly higher than the depths indicated in the pachometer surveys.

DISCUSSION

Initial evaluations at the construction site indicated that the epoxy coating did not meet the requirements of the special provisions for the project, which limited the number of holidays to no more than two per linear foot. Visual inspections and resistivity testing disclosed many flaws and indicated the ineffectiveness of the liquid epoxy supplied for field repairs in providing an adequate coating. This early experience led to a general tightening of the specifications and the acceptance process, which greatly improved the quality of the epoxy coatings. Thus, the findings of the subject evaluation of a poor coating application will have limited applicability. Nevertheless, some useful information was developed regarding the durability of the ECR and its contribution to the durability of the test bridges.

Field evaluations have shown the test bridges to be in good condition after 13 years of service, and there were no indications of significant impending distress. Recent visual inspections also have verified the condition of the structures, to the degree possible, after 16 years under traffic. It is believed that the attainment of proper cover over the reinforcement and the specifying of ECR have combined to provide effective corrosion protection.

The chloride content data in Table 1 demonstrates the contributions of each of these measures. Chloride levels in the uncracked sections reflect the effectiveness of the cover. They remain significantly below the corrosion threshold at a depth just above the top reinforcing mat for all samples except 5 and 6, and it is likely that these samples include some contribution from the nonreactive chlorides bound in the aggregates. The role of the ECR to date has been in resisting the high chloride concentrations in the transverse cracks. Heavily stained cores obtained during the final evaluations provided a visual indication of the aggressive environment in the cracks.

There are several indicators of the effective protection provided to the test decks. Visual inspections have indicated no distress other than the transverse cracking commonly associated with continuous span bridges, and soundings have disclosed no delaminations. Half-cell potentials to a copper-copper sulfate electrode have indicated only three isolated points of active corrosion, those with potentials more negative than -.35V CSE. Increased potentials in the "uncertain" range (-.20 to -.35V CSE) might bear watching were the project to continue, but at present, the three-electrode linear polarization potentials are negative.

Despite the fact that the application of the epoxy coating did not meet the standards established by the FHWA, the ECR has shown reasonable durability. Although the lack of a near-white finish on the surface of the steel may indicate underfilm corrosion, it is not severe, and no debonding of the coating was

evident in any of the cores. The environment does not include constant exposure to liquids, but it does represent some of the more aggressive conditions in Virginia, an interstate highway in relatively harsh climatic conditions.

CONCLUSIONS

Any conclusions reached as a result of this study must be qualified by the realization that its scope is limited to evaluations over 13 years of service of a coating application that does not represent current standards. It is possible, however, that the findings may contribute to some degree toward a resolution of the many questions facing agencies using ECR today. The following conclusions are offered:

1. The combination of adequate depth of cover and ECR has provided excellent protection against corrosion in the decks of the test bridges. No distress is visually apparent 3 years after the completion of the formal evaluations.

2. The coated steel has provided adequate corrosion resistance for the life of the study under exposure to chloride contents well above the corrosion threshold in the transverse cracks in the test decks.

3. Although the steel does not have a near-white finish, there is no sign of significant corrosion or debonding of the coating despite the poor initial state of the coating and its exposure to the elements from the onset of construction until placement of the deck concrete.

RECOMMENDATIONS

Additional information on the durability of ECR and its effectiveness as a corrosion protection system either alone or in combination with other measures is needed by VDOT and other agencies. Although continued research is recommended, the continuation of the subject study, which is based on evaluations of a substandard coating application, is not advised. Instead, more comprehensive studies, such as the one recently contracted by VDOT to the Virginia Polytechnic Institute and State University, should be encouraged.

This study clearly demonstrated the importance of constructing a deck with an adequate cover of high quality concrete in delaying the onset of corrosion. Proper construction procedures must continually be stressed regardless of the employment of ECR or any other protective system.

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Appendix

Special Provision for Epoxy-Coated

Reinforcing Steel

APPENDIX

SPECIAL PROVISION FOR EPOXY COATED REINFORCING STEEL

DESCRIPTION - This work shall include furnishing and placing epoxy coated reinforcing 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° to 85°) 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