

Research Report
KTC-88-2

**CALCIUM NITRITE AS A CORROSION INHIBITOR
IN REINFORCED CONCRETE BRIDGE DECKS**

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16. Abstract The use of calcium nitrite as a corrosion-inhibiting admixture in reinforced concrete has been studied on two bridges - the Kentucky 152 Bridge in Washington County and the Gose Road Bridge in Boyle County. Calcium nitrite was added to concrete used in the slabs, diaphragms and barriers of the KY 152 bridge and only in the slab of the Good Road bridge. Construction of both structures was monitored in the fall of 1986. Placement of concrete on both bridges was satisfactory; however, problems were experienced in finishing the concrete. The finishing problems were related to: 1) concrete "stickiness", 2) use of spinning-drum screed, 3) use of tying for deck grooving and, 4) contractor inexperience with the concrete. The finishing problems included; 1) pulled or exposed aggregate, 2) pull cracks, 3) unclosed surface voids and 4) irregular grooves. Compressive strength of the calcium-nitrite admixed concrete for both bridges exceeded 6,000 psi at 28 days. Freeze-thaw tests of specimens from the Gose Road bridge concrete (that incorporated a super water reducer) indicated no deterioration at 360 freeze-thaw cycles. Half-cell, corrosion-potential tests were conducted on both bridge decks in March 1987. Those tests revealed no active corrosion in either bridge. In July 1987, corrosion-potential and polarization-resistance tests were performed using stainless-steel reference electrodes buried in concrete across the deck of the Gose Road bridge. Those tests revealed that reinforcing steel in the bridge was in a passive state and that no active corrosion was occurring. Recommendations are included on remedying concrete-finishing problems. It is recommended that other experimental bridges be constructed using calcium nitrite.					
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INTRODUCTION

Spalling of reinforced-concrete bridge decks due to chloride-induced corrosion is a widely recognized problem. A number of remedial steps to preclude this problem have been implemented by various states. For new bridges, the most common (and generally considered the most effective) measure is the use of epoxy-coated reinforcing steel. Other preventative steps include use of waterproofing membranes, various types of dense or impermeable concretes in bridge decks and overlays, extra concrete cover over reinforcing steel, cathodic polarization of reinforcing steel and various sealing compounds. For new construction, none of those methods has proven either economically competitive or suitably durable to supplant epoxy-coated reinforcing steel.

The Department of Transportation "Standard Specifications for Road and Bridge Construction" requires the use of ASTM A 615 Grade 60 steel for both epoxy coated and uncoated reinforcing bars in bridges.

The present pre-eminence of epoxy-coated reinforcing steel in protecting bridge decks should not preclude consideration of alternative schemes. The cost of epoxy-coated reinforcing steel could rise due to market fluctuations and in such cases, it would be desirable to have optional methods of corrosion prevention. The use of calcium nitrite as a corrosion inhibitor in reinforced concrete is a promising alternative.

Calcium nitrite was originally used as a corrosion inhibitor in Japan. The scarcity of suitable aggregates forced the Japanese to use marine sand in concrete. That sand contained chlorides which promoted corrosion of reinforcing steel. Research by the Japanese led to the use of calcium nitrite which was determined to be an effective corrosion inhibitor that did not adversely effect the properties of concrete.

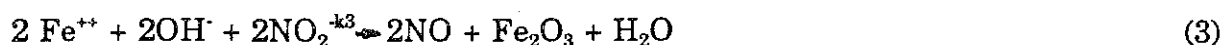
Concrete normally provides a highly alkaline environment in the vicinity of steel (13.5 to 13.8 pH). That renders reinforcing steel passive in normal environments. Use of deicing salts on bridge decks provides chlorides which permeate the concrete and contact the reinforcing steel. Chloride ions attack the passive nature of reinforcing steel in a manner that is not well understood (1). In bridge decks, the effect of chloride ions is to locally shift the potential of reinforcing steel. That occurs both horizontally across the deck and vertically between the upper and lower reinforcing mats. The effect of the potential shift is to create a "macro-cell" type of galvanic corrosion that accelerates the rate of corrosive damage.

The corrosion resistance of reinforcing steel embedded in concrete is suspected as being due to a passive film formed on the surface of the reinforcement. Chloride ions apparently penetrate that layer and transport ferrous ions away from anodic areas on the surface of the reinforcing steel. Corrosion of the reinforcing steel may be viewed as two basic anodic reactions (2):



Reaction 1 is the normal initial corrosion of reinforcing steel which creates a ferrous-hydroxide layer that prevents further corrosion. Reaction 2 is the breakdown of that layer by chloride ions and formation of ferrous oxide away from the anode site on the reinforcing steel surface.

The inhibiting action of calcium nitrite may be represented by a third anodic reaction:



When a nitrite is present, as shown in reaction 3, the corrosion reactions are competitive.

Nitrite ions prevent the migration of ferrous ions from anodic areas. Ferrous hydroxide (formed in reaction 1) and ferrous ions react to form a hydrated ferrous oxide. The ferrous oxide precipitates and forms a barrier on the reinforcing steel that greatly decreases the corrosion potential for reaction 2. As noted, the three corrosion reactions are competitive. If the amount of nitrite ions is sufficiently high compared to the chloride ions, inhibiting reaction 3 proceeds rapidly and stifles additional chloride-induced corrosion.

Calcium nitrite must be added to the concrete in sufficient quantity to neutralize the effect of chloride ions over the life of a structure. Typical dosage rates range from 2 to 4 percent by weight of cement (for W. R. Grace DCI calcium-nitrite admixture). Calcium nitrite has been shown to be effective for chloride to nitrite ratios exceeding 1.5 to 1.0 percent by weight based on original nitrite content (3). At a dosage of 2 percent by weight of cement, calcium nitrite would inhibit the corrosive action if the chloride content in a deck were 2 to 3 percent by weight of cement. This is significant, since 0.3 to 1 percent of chloride by weight of cement in the deck is sufficient to cause corrosion of reinforcing steel, based upon European experience (op. cit. 1). Protection provided by calcium nitrite has been analyzed experimentally and determined to be effective in preventing corrosion at very high chloride levels, 3.6 to 22.6 lbs of chloride per cubic yard of concrete (approximately 0.8 to 5 percent by weight of cement) (4). The potential corrosion-inhibiting properties of calcium nitrite have warranted construction of experimental bridges incorporating its use. That has been done previously by other state highway agencies including Michigan, New Hampshire, Rhode Island, North Carolina, Pennsylvania, and Illinois.

CALCIUM NITRITE IN KENTUCKY BRIDGES

In the fall of 1986, the Kentucky Department of Highways (KYDOH) constructed two experimental bridges incorporating calcium nitrite. Plans were made for a third bridge using calcium nitrite in the pier caps, but that application was eventually cancelled. The two experimental bridges selected were the KY 152 bridge over Beech Fork Creek in Washington County (BRS 5129 - Item No. 4-154) and the Gose Road bridge over Clark's Run in Boyle County (BRM 7104 - Item No. 7-076).

Calcium nitrite was used to protect uncoated reinforcing steel in diaphragms, slabs, and barriers of the Washington County bridge and only on the slab of the Boyle County structure. Black reinforcing steel was used in the members inhibited by the calcium nitrite. A KYDOH special note provided for the addition of W. R. Grace DCI calcium-nitrite corrosion inhibitor. The admixture was to be introduced as an aqueous solution consisting of 30 ± 1 percent calcium nitrite at a solution weight of 10.6 ± 0.1 pounds per gallon. The admixture dosage was to be 4.0 gallons per cubic yard (Appendix D). For 6.6 bags of cement per cubic yard used in KYDOH AA concrete, that resulted in 2 percent calcium nitrite by weight of cement. That dosage should offset the corrosive action of 2 to 3 percent chlorides by weight of cement and provide chloride protection for the functional life of the bridge deck.

KY 152 Bridge

The KY 152 bridge was constructed in late July, 1986. Calcium nitrite was used in concrete placed in three diaphragms. The concrete was batched at the Nally-Gibson Concrete plant at Springfield, Kentucky. The initial concrete mixture included calcium nitrite (W. R. Grace DCI), a retarder (W. R. Grace Daratard 17), and an air-entraining agent (Airlon). W. R. Grace representatives assisted in the batching operation at the plant. Initial attempts to batch satisfactory mixtures using Airlon on July 27 and 29, 1986 failed. Another air-entraining agent, Protex, was successfully substituted. Kentucky Transportation Research Program (KTRP) personnel monitored placement of the diaphragms on July 29, 1986 by the contractor, Judy Construction Company. The final mixture design is given in Table 1.

The bridge site was approximately six miles from the Nally-Gibson plant. When the diaphragm concrete arrived at the site, it had a 3.0-inch slump and a 3.5-percent air content. After five gallons of water were added to the 8 cubic yard batch of concrete at the bridge site, the air content increased to 4.0 percent and the slump remained unchanged.

The deck concrete was placed on August 28, 1986. The first batch delivered to the site was too dry and was rejected. The second batch had a 4.0-inch slump and a 6.1-percent air content at the plant. When it arrived at the bridge, the slump was 2.0 inches and the air content was 5.1 percent. Five gallons of water were added to the mixture to provide workability. Subsequent batches used in the deck varied in (on-site) slump from 4.5 to 6.0 inches and in air content from 5.0 to 6.0 percent.

The concrete was placed by pumping and was finished with a single drum transverse screed transverse finishing machine. Placement proceeded smoothly; however, some problems were encountered in finishing the concrete.

The concrete had a sticky texture and was difficult to strike off with the screed. Material adhered to the screed drum leaving rough, pulled areas on the surface of the concrete after the first pass (Figure 1). The screed had to be run over the same areas again to smooth out the rough concrete surface. At times, a workman would spray water

onto the concrete to enhance finishing. Later in the deck-placing operation, the cement content was increased from 6.6 to 7.0 bags per cubic yard to enhance workability. Except for finishing problems, concrete placement proceeded satisfactorily and the deck was completed by the end of the day.

KTRP personnel did not monitor any barrier concrete-placement operations.

Gose Road Bridge

The Gose Road Bridge incorporated calcium nitrite only in the deck concrete. The decision was made to use a super water reducer (Daracem 100 Type G) instead of a retarder for that bridge. The initial design mixture is given in Table 2. The material was batched a few miles from the bridge site at the Concrete Materials Inc. plant in Danville. The calcium nitrite solution was dosed at the plant by pumping.

The bridge was a short 45-degree skewed structure having a slight grade. The Jim Skaggs Construction Company placed the deck on October 7, 1986.

The specified AA Concrete slump was $3 \pm 1/2$ inches and the specified air content was 5.5 ± 1.5 percent. The slump of the first batch was 2-3/4 inches and the air content was 4.8 percent. Additional water (10 gallons) was provided at the site to increase the slump to about 4-1/2 inches. The contractor was unwilling to use a greater slump (5 to 6 inches requested by W. R. Grace personnel) because he feared the concrete would run during placement due to inclination of the deck.

The first batch of concrete was not manually finished promptly. That was due to delays in adding water to achieve the desired slump and to the amount of time required to clear the obliquely mounted finishing machine for transverse manual finishing (bull floating and tyning) across the width of the deck. The concrete began to harden and was difficult to finish. The sticky texture of the concrete exacerbated the problem.

Placement and finishing improved toward the upper end of the bridge after W. R. Grace personnel convinced the contractor to allow the specified 5 to 6- inch slump. The mix design air content was specified to be $5.5\% \pm 1.5\%$. During placement it varied between 4.8 and 5.0 percent.

EVALUATION OF THE EXPERIMENTAL BRIDGE DECKS AND CONCRETE

KTRP personnel inspected the bridge decks in December 1986 (5). The surface finish of both decks was not good. Pull cracks were detected along the north edge of the KY 152 bridge deck (Figure 2). That deck was observed to have irregular tyning varying from almost flush to approximately 1/4-inch deep. In areas where tyning was deep, aggregates were pulled from the concrete giving the deck a "pock-marked" appearance. Several small areas where plastic shrinkage cracking occurred had been sealed with epoxy.

The Gose Road deck also exhibited an irregular surface (Figures 3 and 4). Uneven tyning was noticeable, especially on the lower end of the bridge where the tyning depth was shallow. That portion of the deck surface apparently had been finished and tyned after the concrete had stiffened. Deep tyning had pulled loose or exposed aggregate at many points on the deck; however, pull cracking was not detected. Some surface voids were present where the concrete had not been completely consolidated during placement.

Surface finish problems were not indicative of the calcium-nitrite admixed concrete strength and durability. Concrete cylinders cast at the KY 152 bridge had average compressive strengths of 5,340 psi, 5,627 psi and 6,420 psi at 5, 7, and 28 days, based on two, four and five tests at the respective time intervals. The Gose Road bridge concrete cylinders had average compressive strengths of 6,110 psi and 7,260 psi at 7 and 28 days, based on two tests at each time interval. In part, the strength difference may be due to the use of a super water reducer in the Gose Road bridge concrete.

Freeze-thaw tests were performed on two concrete prisms cast from concrete batched for the Gose Road bridge. The prisms were tested in accordance with ASTM-666 Method B, Freezing in Air and Thawing in Water and ASTM C-215, Fundamental Transverse ... Frequencies of Concrete Specimens. The specimens were soaked 13 days prior to freeze-thaw testing that commenced on October 20, 1986. The concrete prisms met both ASTM and Kentucky Specifications (300 and 350 freeze-thaw cycles) prior to the dynamic (sonic) modulus reaching 60 percent of the initial modulus. The prisms were not monitored for expansion. Since there was no reduction in modulus after 360 cycles of rapid freezing and thawing, it may be safe to assume the concrete expanded less than the 0.050 percent (the maximum value recommended for concrete specimens by KYDOH Division of Materials).

Unfortunately, prisms of class AA concrete, which normally would have been specified for this project, were not cast for freeze-thaw comparison testing. As a result, a direct comparison of the freeze-thaw durability of class AA concrete containing calcium nitrite and conventional class AA concrete is not possible. However, a review of past freeze-thaw data at the Kentucky Department of Highways' Division of Materials indicates that coarse aggregate used in the concrete mixture for the Gose Road bridge has been approved for size No. 78's and No. 8's only. Durability factors for these sizes are only slightly less than 100 percent.

CORROSION TESTING

At the onset of this work, KTRP and W. R. Grace personnel intended to install special stainless-steel reference electrodes in both decks. Those electrodes were to be custom made by W. R. Grace and installed by their personnel. In June 1986, work on the KY 152 Bridge proceeded faster than anticipated and electrodes could not be furnished for that bridge in time for installation. W. R. Grace personnel stated they could eventually perform polarization-resistance tests without the buried reference electrodes. That method will be used on future tests conducted over the next several years when more meaningful corrosion-rate data are expected.

In October 1986, W. R. Grace personnel installed four reference electrodes along a transverse reinforcing bar on the top mat of the Gose Road deck. The probes were placed: 1) 12 inches from the curb in the gutter line, 2) 8'-8" from the curb under the center of the northbound lane, 3) 12'-5" from the curb under the left wheel-track area in the northbound lane and 4) 16 feet from the curb in the center of the bridge. The probes were embedded when the deck was placed. Lead wires were run to a small junction box cast into the outer face of the east barrier. The wires were color coded for identification.

In December 1986, KTRP personnel performed half-cell (saturated copper-sulfate) corrosion-potential tests on the two decks. For each test, the probe lead wire was grounded to a gutter. Test results are shown on Figures 5 and 6. Active corrosion was not detected (i.e., corrosion potentials measured were less than 337 mV). However, some corrosion potentials were measured in the 300-mV range. Those high readings are typical of new bridges and are expected to decrease with time. A low oxygen concentration may occur in concrete containing calcium nitrite which may cause such high readings. It is too early in the service lives of the bridges to expect any significant corrosion (whether the calcium nitrite is beneficial or not).

On July 24, 1987, W. R. Grace and KTRP personnel visited the Gose Road bridge to perform corrosion measurements in conjunction with the reference electrodes embedded in the deck. A series of corrosion measurements were taken on the embedded corrosion cells (Figure 7). The ambient temperature was 90° F and the deck temperature was 95° F.

Polarization-resistance measurements were made with a computer-controlled potentiostat, the AUTOSTAT, made by Thompson Electrochem LTD (Figure 8). Reference voltages were first measured between each of the buried 316 stainless-steel reference electrodes and the reinforcing steel. The AUTOSTAT then slowly varied the direct-current potential between the reinforcing steel and a reference electrode at a rate of 2 mV per minute from -20 to +20 mV. The computer measured both the instantaneous voltage and current. The polarization resistance, R_p , was measured as the slope of the instantaneous voltage versus the instantaneous current curve at $I_p=0$. That process was repeated for each reference electrode. Half-cell potential measurements were taken with both copper-sulfate and calomel half-cell electrodes (the calomel cell produced lower corrosion-potential values). The test results are shown in Table 3.

The test results indicate that little, if any, corrosion was occurring (6). The reinforcing-steel potentials were passive in respect to the stainless-steel reference electrodes. That indicated the reinforcing steel was more corrosion resistant than the stainless steel at the time of the readings. The half-cell corrosion-potential readings revealed the presence of a galvanic current when attached to the zinc-coated guardrail. The distance over which that weak current was detected indicated that the concrete was relatively permeable and that the concrete resistivity was low. W. R. Grace personnel estimated that an area of about 10,000 cm² was polarized across the deck. Considering a polarization resistance of about 52 ohms, the product of the polarization resistance and

steel surface area over which it acts is 500 kohms-cm² which is high for steel, indicating that no corrosion is occurring (7).

Comparative cost data were obtained for the calcium nitrite and epoxy coating corrosion-protection methods. The KY 152 and Gose Road bridges used 273.4 and 31.6 yard of class AA concrete, respectively. Mr. Jim Render of W. R. Grace Company provided a unit cost of \$24 per yard for DCL, Daracem 100 (super water reducer), and the additional air-entraining agent. If that mix design had been used in both bridge decks, the additional cost would have been \$6,561 and \$758, respectively.

The KY 152 and Gose Road bridges used 57,579 and 6,763 lbs of reinforcing steel, respectively, that would normally employ epoxy coating. The cost of epoxy coating is \$0.104 per pound based on 1988 Kentucky Transportation Cabinet data. If epoxy coating had been used on both bridges, the additional cost would have been \$5,998 and \$703, respectively.

Costs of the two corrosion-protection methods are similar. The calcium nitrite method is slightly higher. However, that difference is negligible when compared to the price of the structures.

CONCLUSIONS

Corrosion tests performed on the two experimental calcium-nitrite impregnated bridge decks revealed no active corrosion. However, the tests were too premature to predict future performance. FHWA research (op. cit. 4) indicates that for the calcium-nitrite dosages provided for the two bridges, they should provide corrosion protection similar to that provided by epoxy-coated reinforcing steel (in the top mat).

It is likely that a long time will be necessary for the two bridges to experience significant corrosion. That belief is due not only to the protection afforded by the calcium nitrite, but also to the low amount of deck salting that is anticipated for the two decks based on their locations. Portions of the two bridge decks could be deliberately salted to promote corrosion. It would be more desirable to use calcium nitrite on bridges in northern areas of the state that are subject to more applications of deicing salts.

Finishing was the main construction problem with concrete containing calcium nitrite. That problem was not evident when placing barriers or diaphragms, but only in finishing deck surfaces. Calcium nitrite renders concrete sticky similar to microsilica. Occasionally, concrete sticks to the surface of the spinning drum of a finishing machine. That creates rough areas in the finished surface of the deck.

When an experimental microsilica concrete overlay was placed on a deck at Seebree, the finishing problem was eliminated by substituting a vibrating-screed for the more common spinning-drum, Bidwell type screeds. Kentucky Department of Highways personnel have expressed concern with using a vibrating screed during construction of

new decks. It would be possible to modify spinning-drum screeds to provide a greater stroke, thereby eliminating some excess working of the concrete surface. It should be noted that both decks were finished with single-drum screeds. The newer double-drum screeds would probably perform better.

An improved surface finish could be obtained by grooving a cured deck by sawing rather than by tyning a deck when the concrete was in a plastic state. That might further reduce finishing problems presently encountered during tyning.

For any new bridges incorporating calcium nitrite, close interaction should be promoted between the calcium-nitrite suppliers, concrete suppliers, and contractors to prevent problems similar to those experienced on the previous experimental decks. Some preliminary experimental work with finishing procedures and concrete mixtures would be desirable to optimize the concrete properties and improve concrete finishing of further experimental decks.

Use of super water reducers in concrete having 5-to 7-inch slumps may promote better workability of calcium nitrite-modified concrete. Super water reducers can be used to achieve low water/cement ratios and superior freeze-thaw resistance (though some problems have recently been encountered in this area with a specific super water reducer). Super water reducers used in conjunction with calcium nitrite also will yield stronger concrete than the conventional class AA mix. Super water reducers should also be studied separately since they may provide significant improvement of bridge-deck concrete used with epoxy-coated reinforcing steel.

Calcium nitrite also may be used with microsilica and super water reducers to produce very strong concretes that are impermeable to chloride penetration, resistant to reinforcing-steel corrosion, resistant to creep, resistant to abrasion, and resistant to freeze-thaw damage (8). Concrete containing those additives would be expensive and might only be justified in critical applications such as long prestressed beams or bridge decks carrying high traffic volumes. Additional developmental work is needed for those applications.

It would be desirable for the Department of Highways to continue developmental work with calcium nitrite. That consideration was noted in a previous departmental memorandum (9).

RECOMMENDATIONS

The following recommendations are provided to continue research and developmental work with calcium nitrite.

1. Work should be conducted to improve the finish of calcium-nitrite concrete decks. Experimental laboratory design work should be conducted to develop an improved calcium-nitrite concrete that incorporates super water reducers. That concrete should be field tested in conjunction with a screed that will not excessively work the concrete during finishing. This work should be performed prior to constructing other bridge decks with calcium nitrite in the concrete.
2. Additional bridge decks should be constructed incorporating the improved calcium-nitrite concrete and modified screed. Department of Highways officials should also consider using calcium nitrite in other bridge elements such as pier caps where chloride-induced corrosion can be a problem.
3. Laboratory work should be conducted to develop a concrete mix design incorporating calcium nitrite, super water reducers, and microsilica. That concrete could be employed on decks of new or rehabilitated bridges having high traffic volumes.

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TABLE 1. Concrete Mixture Used for the Deck of the KY 152 Bridge
over Big Beech Creek in Washington County

ITEM	DESCRIPTION	QUANTITY
1.	Calcium Nitrite (DCI)	4 gal/yd ³ *
2.	Water	30 gal/yd ³
3.	Cement	6.6 bags/yd ³ **
4.	Coarse Aggregate (60 percent)	1,914 lb/yd ³
5.	Fine Aggregate (40 percent)	1,287 lb/yd ³
6.	Retarder (Daratard 17)	6 oz/100 lb cement
7.	Air entraining agent (Protex)	5 oz/yd ³

* See Special Note for calcium nitrite inhibitor in the appendix.

** Increased to 7.0 bags/yd³ for a portion of the deck placed later.

TABLE 2. Concrete Mixture Used for the Deck of the Gose Road Bridge over Clarks Run in Boyle County.

ITEM	DESCRIPTION	QUANTITY
1.	Calcium Nitrite (DCI)	4 gal/yd ³
2.	Water	26 gal/yd ^{3*}
3.	Cement	6.6 bags/yd ³
4.	Coarse Aggregate (60 percent)	1,817 lb/yd ³
5.	Fine Aggregate (40 percent)	1,177 lb/yd ³
6.	Super Water Reducer (Daracem 100 Type G)	14 oz/100 lb cement**
7.	Air Entraining Agent (Russtech)	8 oz/yd ³

* Increased between 28.1 to 28.9 gal/yd³ in subsequent batches.

** Use restricted to keep slump less than 5 inches.

TABLE 3. Reinforcing Steel Corrosion Measurements from the Gose Road Bridge over Clarks Run in Boyle County - June 24, 1987.

PROBE #	LOCATION	REBAR POTENTIAL vs 316SS (mV)*	CORR. POTENTIAL CSE**(mV) SCE***(mV)		POLAR. RESISTANCE
1.	12" (Gutter Line)	25	-200	-138	42
2.	8'-8" (Center of Lane)	30	-220	-150	52
3.	12'-5" (Tire Track)	14	-220	-144	52
4.	16'-0" (Center of Deck)	42	-210	-137	55

* Data furnished by W. R. Grace August 2, 1987

** Copper Sulfate Electrode

*** Saturated Calomel Electrode.

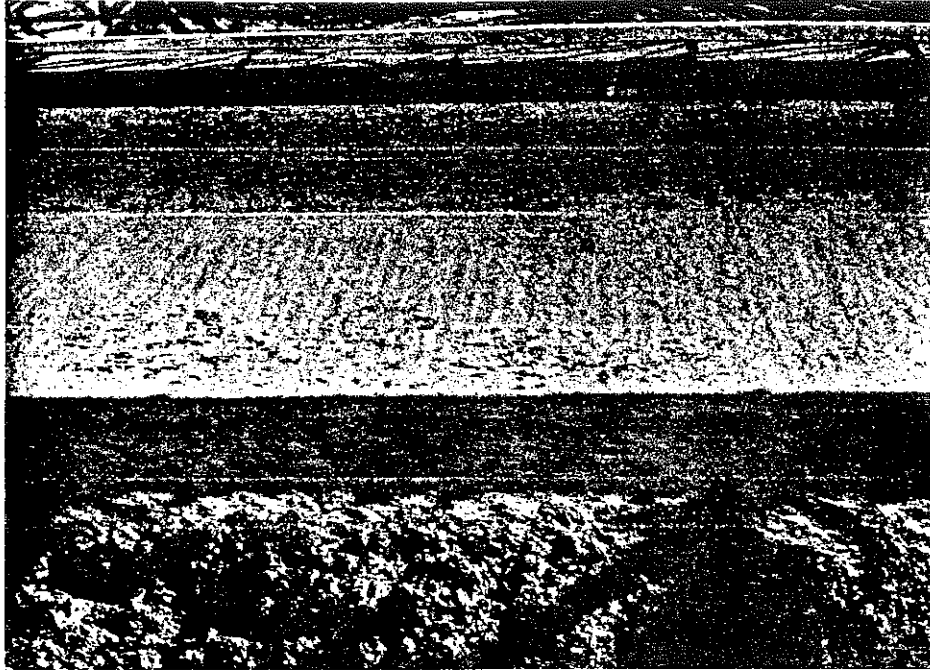


Figure 1. Rough Concrete Surface Texture after Initial Finishing with Spinning-Drum Screed KY 152 Bridge (August 28, 1986).

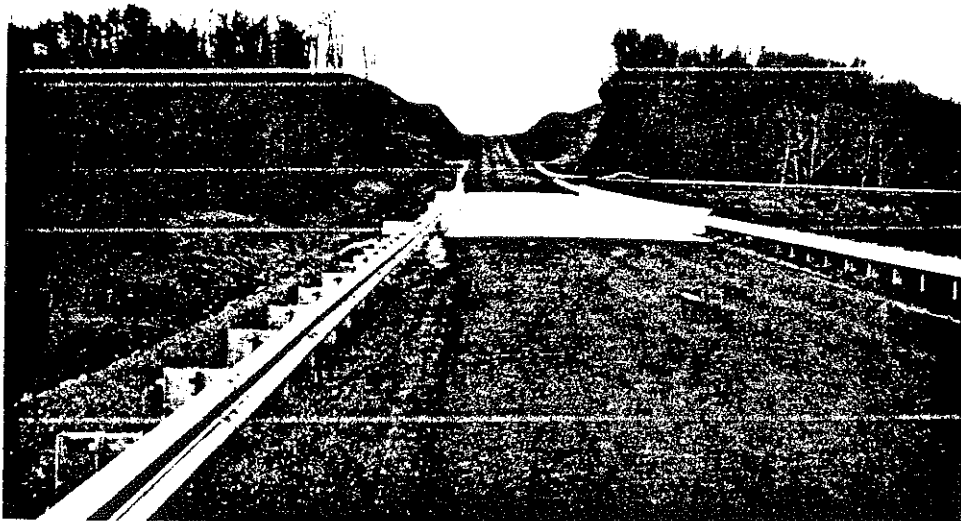


Figure 2. KY 152 Bridge (December 1986).

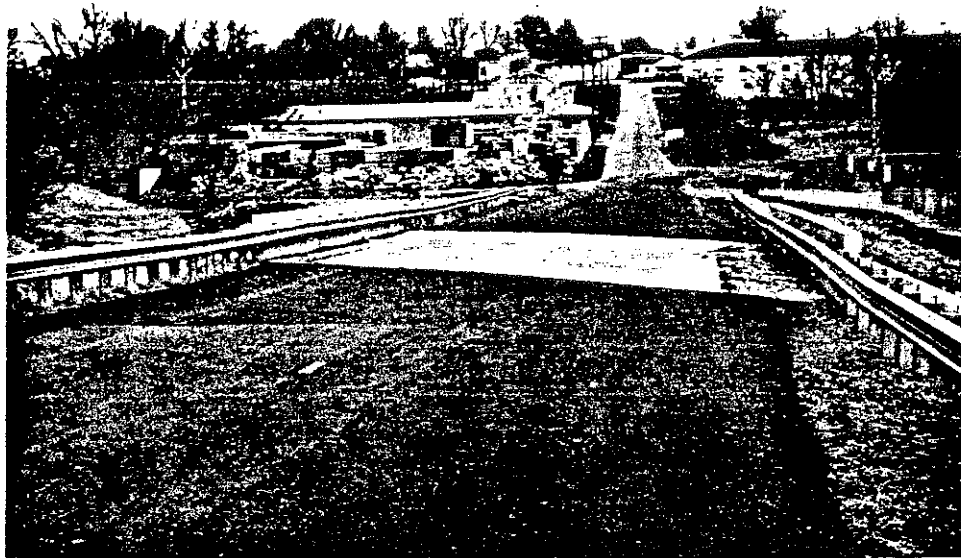


Figure 3. The Gose Road Bridge (December 1986).



Figure 4. Irregular Grooved Finish on the Gose Road Bridge Deck (December 1986).

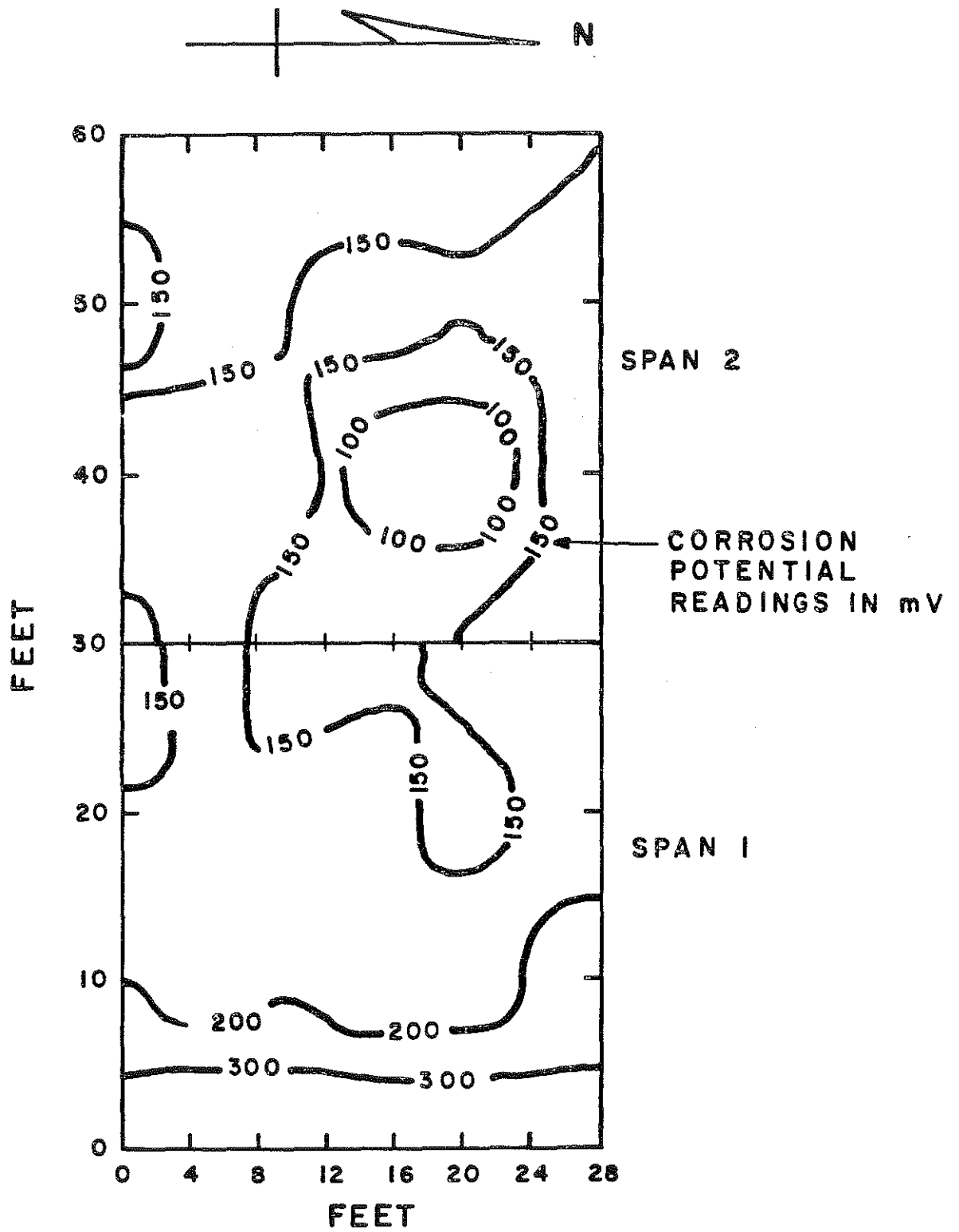


Figure 5a. Corrosion Potential Test of the KY 152 Bridge - Spans 1 and 2 (March 1987).

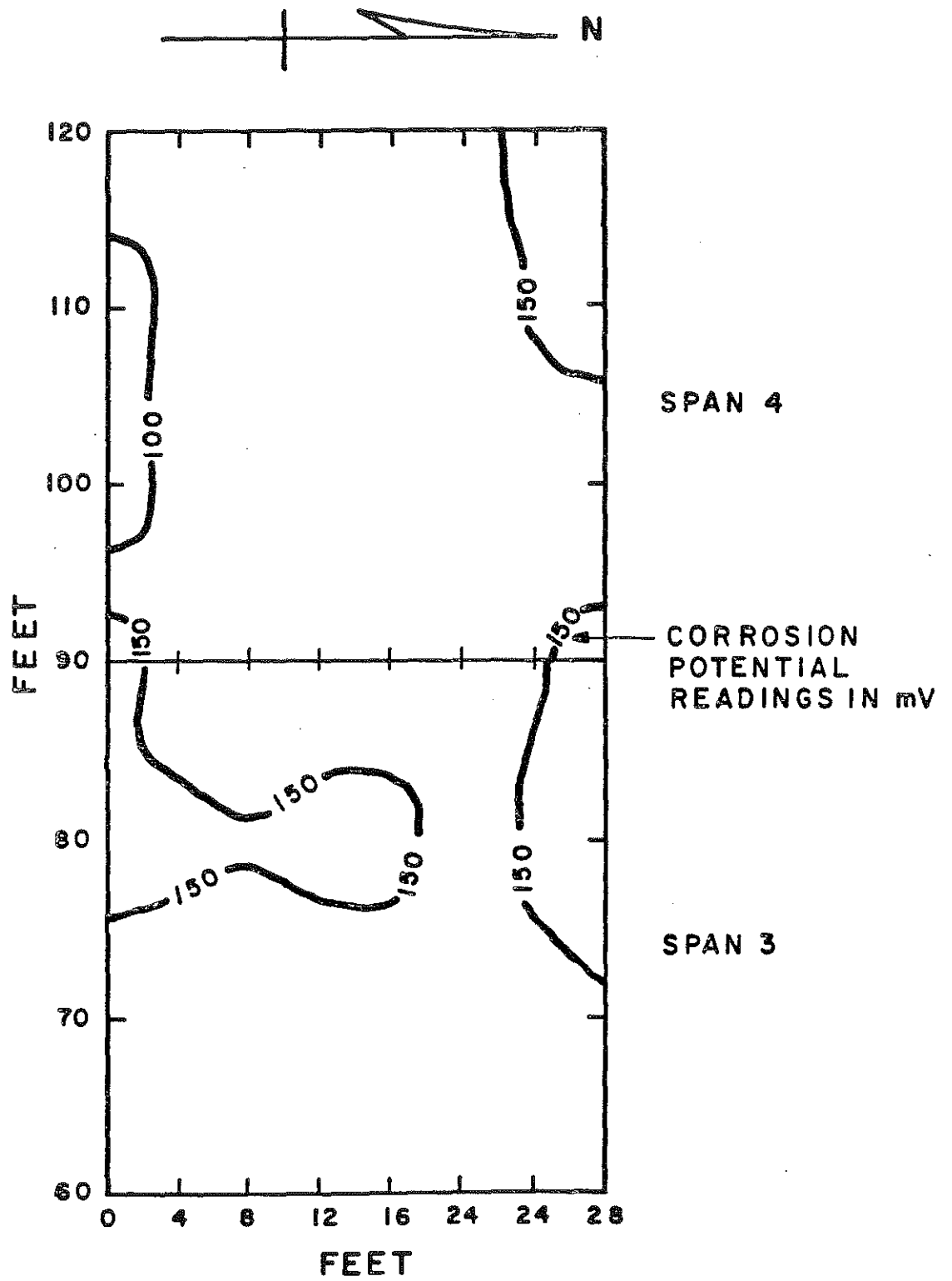


Figure 5b. Corrosion Potential Test of the KY 152 Bridge - Spans 3 and 4 (March 1987).

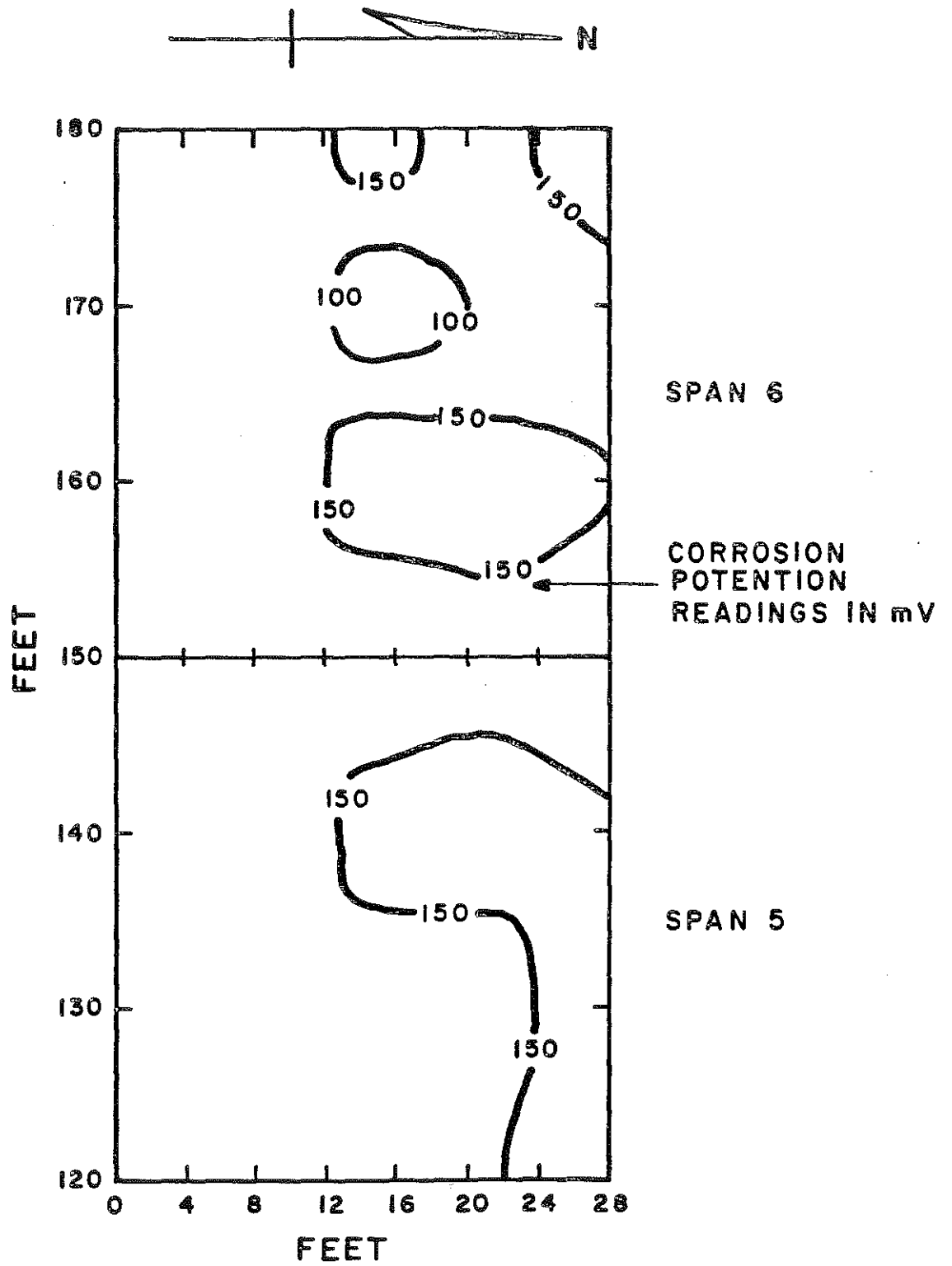


Figure 5c. Corrosion Potential Test of the KY 152 Bridge - Spans 5 and 6 (March 1987).

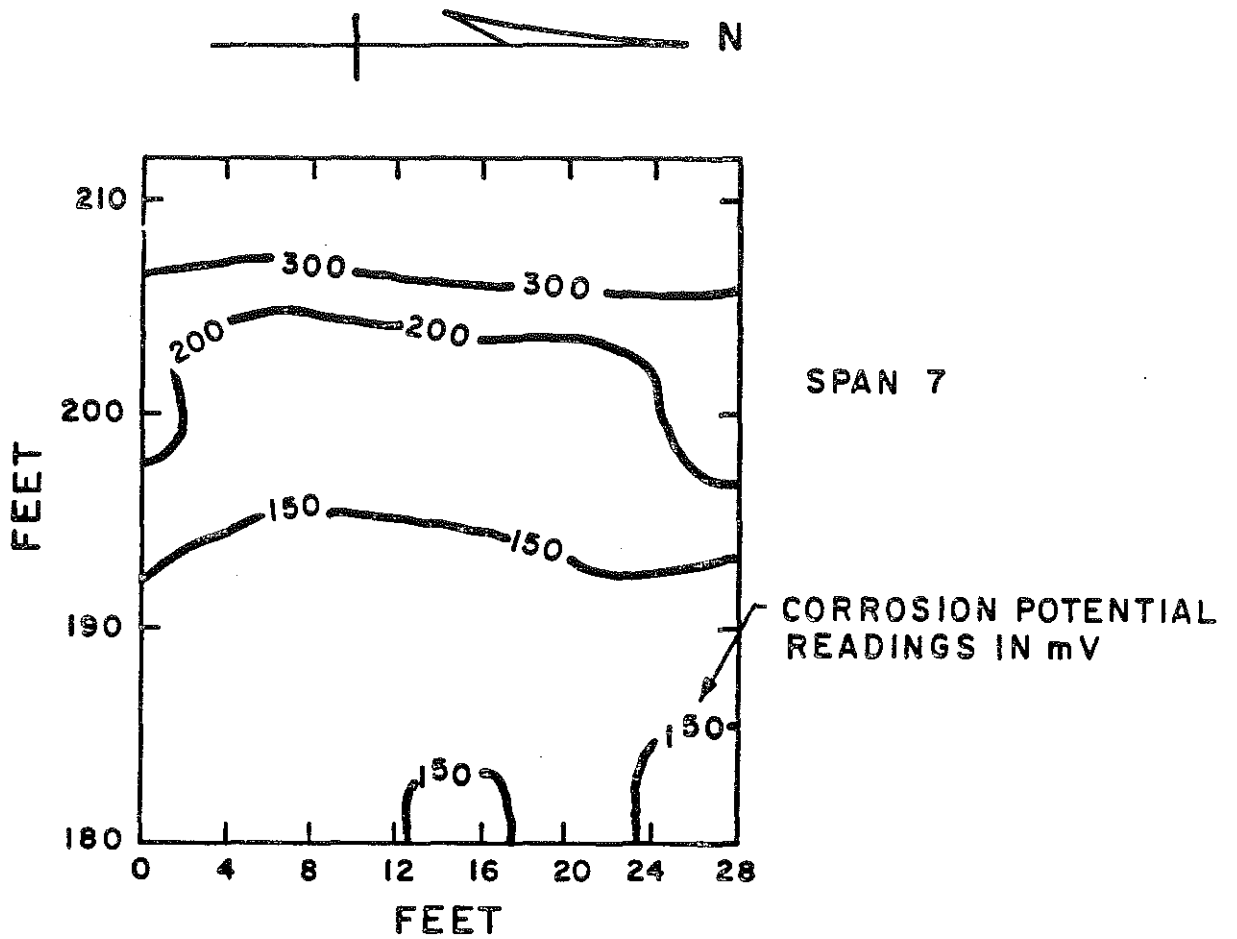


Figure 5d. Corrosion Potential Test of the KY 152 Bridge - Span 7 (March 1987).

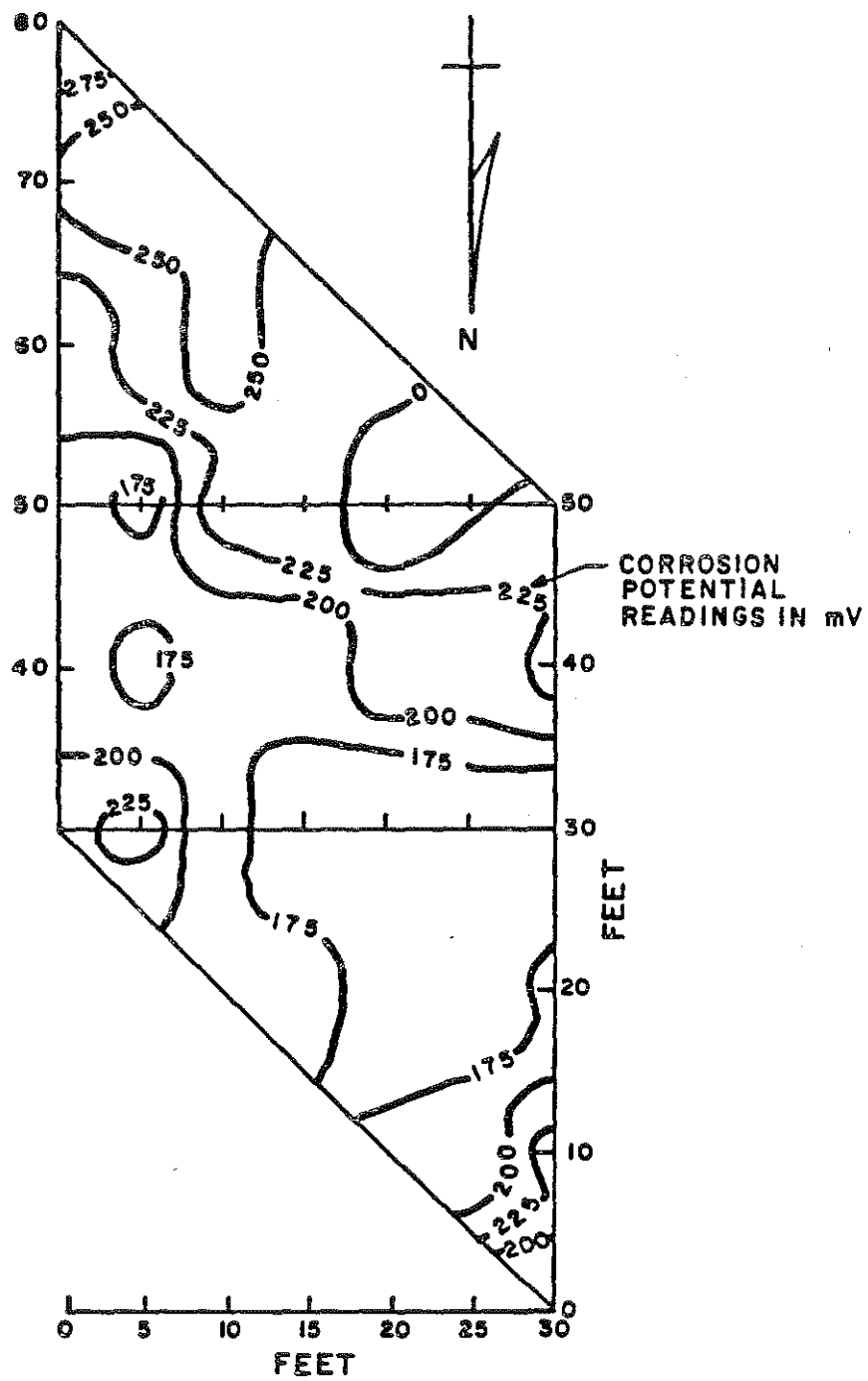


Figure 6. Corrosion Potential Test of the Gose Road Bridge (March 1987).

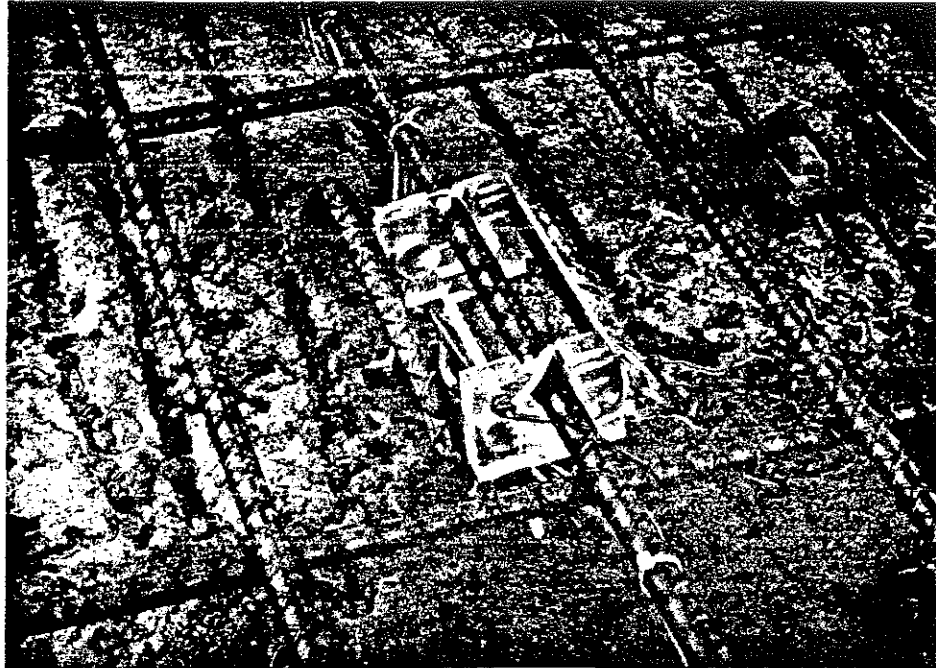


Figure 7. Stainless Steel Reference Electrode Installed on a Transverse Rebar in the Gose Road Bridge (October 1986).



Figure 8. Polarization Resistance Measurements Being Taken of the Reference Electrodes Buried in the Deck of the Gose Road Bridge (July 24, 1987).

APPENDIX

(Transportation Cabinet Special Note for Calcium Nitrite Corrosion Inhibitor Used in the KY 152 and Gose Road Bridge Decks)

SPECIAL NOTE FOR
CALCIUM NITRITE CORROSION INHIBITOR
(EXPERIMENTAL)

I. DESCRIPTION

This work shall consist of furnishing and adding calcium nitrite corrosion inhibitor to reinforced concrete in the locations designated on the plans or in the proposal.

II. MATERIALS

The corrosion inhibitor shall be an aqueous solution and shall be W. R. Grace's DCI Corrosion Inhibitor or approved equal. The solution shall contain 30 ± 1 percent calcium nitrite by weight and shall weigh 10.6 ± 0.1 pounds per gallon.

III. CONSTRUCTION REQUIREMENTS

The calcium nitrite solution shall be added to the concrete mixture at the rate of 4.0 gallons per cubic yard. Precautions shall be taken to ensure that the solution does not contact other admixtures before entering the concrete. Air entraining, water reducing, or water reducing and retarding admixtures shall be compatible with the calcium nitrite solution. Calcium nitrite acts as an accelerator in addition to inhibiting corrosion of the steel, and adjustment in quantities of other admixtures to produce acceptable workability and setting time may be required.

The calcium nitrite solution shall be added immediately after the other admixtures have been incorporated into the mixture. Precautions shall be taken to ensure that the solution does not contact other admixtures before entering the concrete. The water in the calcium nitrite solution shall be considered as part of the mixing water.

The manufacturer of the calcium nitrite solution shall provide a representative to assist the Contractor and the Engineer when use of the material begins, and to be available on request during subsequent construction.

IV. MEASUREMENT AND PAYMENT

No separate measurement or payment will be made for furnishing and incorporating the calcium nitrite solution into the concrete mixture. The cost of furnishing and incorporating the admixture, and furnishing a manufacturer's representative for technical assistance, is considered incidental to the contract unit price for the concrete in which the admixture is used.

August 15, 1985