Texas State Department of Highways
and Public Transportation

Interim Report

Polymer Concrete Overlays

Agreement DOT-FH-11-8608, Task Order No. 18
FCIP Study No. 1-3D-80-542

By

Ralph K. Banks, Donald L. O'Connor,
H. D. Butler, David Hustace
and Franklin S. Craig

January 1982

ABSTRACT

This interim report is to report on the status and performance to date of an experimental bridge deck overlay of polymer concrete consisting of 4 courses of polyester-styrene resin monomer and sand aggregate.

The primary purpose of such an overlay is to bar against moisture penetrating into the top surface of the concrete and perpetuating corrosion of the reinforcing steel, and also to keep away further chloride contamination.

ACKNOWLEDGEMENTS

The able advice, assistance and encouragement of Mr. John Bartholomew of the FHWA Office of Development who was Project Manager for this Study, is gratefully acknowledged. The on-site assistance and reporting of Mr. Ronald P. Webster of Brookhaven National Laboratory is also acknowledged.

Assistance in laboratory testing of the overlay was provided by Billy N. Bannister and Fred A. Schindler of the Department's Materials and Tests Division.

Table of Contents

1.0 Introduction

Background

Deterioration of concrete bridge decks has in recent years become a major problem in highway maintenance, especially in the northern portions of the State. It has been concluded that the primary cause of this deterioration is cracking and spalling caused by expansion forces which develop within the concrete as the result of the accelerated corrosion of reinforcing steel induced by intrusion of deicing salt (chlorides) contaminated moisture.

While elimination of chlorides from a deck may not be practical once contamination has taken place, it is reasoned by many that if moisture instrusion from the top surface can be stopped by the placement of an impermeable barrier, then corrosion activity can be slowed and eventually stopped. Of course such a barrier would also turn away chloride bearing moisture and therefore avoid further contamination.

It was then decided to investigate the use of a polymer concrete (PC) overlay for effectiveness in providing such a barrier, and feasibility of both construction and cost. Such an overlay has shown a high degree of success as an impermeable barrier in other experimental installations. (1)

Structure Location and Description

The structure overlayed is the US Highway 277 (Southbound) Gilbert Creek Bridge located approximately 2 miles south of Burkburnett and 8 miles north of Wichita Falls, Texas. (2), (3). The structure carries one-way (southbound) traffic.

The concrete deck has a 44 foot roadway with 3-45 foot prestressed concrete girder spans. Construction was approximately 1965.

Deck Condition

The deck was not covered prior to the overlay. There was minor cracking on the end spans and major cracking on the center span. There was also some very minor scaling but no spalling. (3) No patching was necessary.

Overlay System

The overlay was built up of 4 courses of monomer liquid and fine aggregate (sand). Materials and techniques were developed by Brookhaven National Laboratory of Upton, New York, referred to as "Thin Polymer Concrete Overlay - Method B". (1)

Personnel Placing Overlay

Personnel placing the overlay were from the Wichita Falls District (District 3). This District has successfully placed polymer concrete overlays on three bridges previously, using a methyl methacrylate system developed at the University of Texas at Austin Center for Highway Research.

2.0 Materials

Monomer Liquid

The monomer liquid used consisted of a monomer, coupling agent, wetting agent, promoter, co-promoter and an initiator as follows: (3)

Component	**Chemical**	**Weight%**
monomer	unsaturated polyester-styrene monomer resin solution	100
coupling agent	gamma-methacryloxy propylthimethoxysilane (MPS)	1
wetting agent	ethoxylated-accetylenic (EA)	1
promoter	cobalt naphthenate (CoN) (6% cobalt)	1
co-promoter	nn-dimethyl paratoluidine (DMPT)	.04 to .05
initiator	methyl ethyl ketone peroxide (MEKP)	1.2 to 1.8

The monomer was USS Chemical LB183-13 blend or equivalent; the coupling agent was Union Carbide A-174 Silane or equivalent; and the wetting agent was Air Products & Chemical Surfanol S-440 or equivalent. (1, 3)

The 1 wt % of CoN is twice as much as is normally used. This additional amount of promoter was necessary due to an error made by the manufacturer during processing of the monomer. (3) The co-promoter was used due to the low ambient temperatures, and the amounts used were varied depending upon the temperature. (3)

Sand

The sand was of Nos. 1A and 00 grades in sieve analyses as follows: (3)

No. 1A

Size	% Passing
8	100
10	98
16	47
20	4
30	0-1

No. 00

Size	% Passing
4	100
8	49
10	16
16	0-1
20	0-1

The sand was purchased from the Texas Mining Co., Arlington, Texas.

3.0 Application Procedures

Deck Preparation

The surface of the deck was initially cleaned by sandblast. No patching of the deck was necessary. (3)

Monomer Liquid Mixing and Application

To eliminate as much field mixing as possible the monomer, and the coupling and wetting agents, and the promoters were pre-blended into 55 gallon drums at the Maintenance Section Warehouse before delivery to the job site. (3,4)

The monomer liquid was drawn in 5 gal pails of from 40 to 42 lbs each. The initiator for each pail was measured volumetrically and added just prior to application. For each course the liquid was poured directly onto the deck and spread using push brooms. (3).

Sand Application

For each course, the sand was spread over the monomer liquid using a dump truck with tailgate spreader supplied by FHWA which was previously obtained from the Oregon DOT. A medium pneumatic, rubber tired roller was used to compact the sand into the liquid as the liquid began to gel. After the monomer liquid had hardened, the excess sand was removed using a power broom. The excess sand was not reused.

Courses 1 and 2 consisted of the No. lA sand, and the No. 00 sand was used in courses 3 and 4.

General Procedure

In order to minimize safety hazards and expedite placement of the overlay, all traffic was diverted from the bridge to an adjacent service road between the hours of 9 a.m. and 4 p.m. (3) This allowed for the placement of each course over the entire width of the bridge before beginning placement of the subsequent course. (3)

To assist in the placement of the overlay, the deck was divided up into five 7-ft wide strips and one 4 1/2-ft wide strip. Each course of the overlay was placed one strip at a time over the entire length of the bridge. To avoid developing a ridge along the joints between the strips and to help seal the joints, the joints were staggered from one course to the next by moving the location of the 4 1/2-ft wide strip from one side of the deck to the other.

4.0 Application Itinerary

First Day—The first course was placed over one-half of the deck (three of the 7 ft wide strips).

Weather Conditions—partly sunny, very windy with temperature of 52°F at 1:00 P.M.

MEKP Concentration: 1.8 wt %

DMPT Concentration: 0.05 wt %

Monomer Liquid Application Rates: Course 1 (half of the deck)—1.58 lb/sq yd (12 pails)

Second Day—The rest of the first course was placed as well as all of the second course.

Weather conditions: sunny and clear, light wind with temperature during the placement of the first course at about 47°F at 10:00 A.M. Temperature at the time of placement of the second course was about 62°F at 1:00 P.M.

MEKP Concentration: 1.8 wt %

DMPT Concentration: Course 1- 0.05 wt %; Layer 2-0.04 wt %

Monomer Liquid Application Rates: Layer 1 (less than half of the deck) 1.39 lb/sq yd (9.25 pails). Layer 2 (entire deck) - 2.18 lb/sq yd (31 pails).

Third Day—Placed third and fourth courses.

Weather Conditions—sunny and clear, light wind with ambient temperature during placement of third course of 52°F at 10:00 A.M. Ambient temperature during placement of fourth layer was 69°F at 1:00 P.M.

MEKP Concentration: Layer 3-1.8 wt %. Layer 4-1.2 wt %.

DMPT Concentration: Layer 3-0.05 wt ^{7}. Layer 4-0.03 wt ^{7}.

Monomer Liquid Application Rates: Layer 3-2.33 lb/sq yd (33.25 pails). Layer 4-3.30 lb/sq yd (47 pails).

General Comments

A total of approximately 5514 lbs of monomer liquid (12.25 drums) was used to overlay the entire bridge deck.

Application of the overlay, generally, went smoothly and only a few problems, relating to the actual placement of the overlay, were encountered. (3)

Approximately a 70 sq ft area of the first layer, placed on the first day, was damaged while being rolled when the roller ran up against the curb and became stuck. While trying to free the roller, the semi-gelled resin under the roller was torn, resulting in a disbondment of the layer from the deck surface. No special measures were taken to repair this area. The resin was allowed to cure overnight and the spots were simply covered over during placement of the second layer. The damaged area was located on the outside shoulder at the northwest corner of the bridge.

During the placement of the fourth layer, two sections of resin began to gel before the sand could be spread. These sections were located along the inside shoulder at the southwest corner of the bridge. These areas were repaired by placing a fifth layer over the bare spots.

Heavy rains fell in the area two days before the first day of placement. However, by the afternoon of the first day the surface of the deck appeared to be dried sufficiently, by the strong winds and by the sandblasting operation, to place the overlay. The deck was sandblasted during the day before the first day and the morning of the first day.

Laboratory tests indicated that at an ambient temperature of 46°F the LB183-13 polyester resin had a gel time of 10 to 13 min (for a 200 gm sample) when using the following initiator-promoter system:

1.8 wt % MEKP (9 % oxygen), 1.0 % CoN (6 % active cobalt), and 0.05 wt % DMT.

5.0 Tests

5.1 Initial Testing

Initial testing prior to placement of the overlay consisted of the taking of 8 each 4-inch cores, half-cell potential corrosion readings, and skid tests as shown in Appendices A, B and C respectively. As shown in Appendix A the 4-inch cores were analyzed for the amount of chlorides contained in the concrete down to the level of the reinforcing steel in both the structure overlaid and the adjacent northbound structure.

As shown in Appendix C, the skid measurements were taken at 20, 30, 40 and 50 mph in each travel lane by averaging 5 tests at each speed of each lane.

The taking of wear measurements in the wheel paths was attempted using a straight-edge, and no measurable wear was noted.

Samples of the sand proposed for use were submitted to FHWA.

The deck was chain dragged for delamination and none was found.

5.2 Testing During and After Overlay Placement

Four (4) each Matcor Corrosometer probes (6) were installed in the deck just prior to placement of the overlay to evaluate the rate of corrosion of the reinforcing steel. Four (4) other corrosometer probes were installed in the adjacent structure carrying the northbound traffic which remained uncovered. This was done to provide a means of determining effectiveness of the overlay relative to an uncovered deck with similar exposure conditions. Corrosometer readings were taken each month after overlay placement. Readings up through one rear are shown in Appendix D. Readings could not be taken some months due to high water underneath the structure. Information on the corrosometer probes is also provided in Appendix D.

Both immediately after placement of the overlay and after one year, the deck was chain dragged. No significant indication of ineffective bonding was found in either instance. Also, no wear of any significance was found after one year.

Skid measurements at 20, 30, 40, and 50 mph in each travel lane were taken by averaging 5 tests, at each speed, in each lane as shown in Appendix C.

Four (4) each 4-inch cores were taken for performance of the 90-day chloride ponding test with results as shown in Appendix E. Twenty-one (21) each 3-inch cores were taken and subjected to shear bond strengths of the overlay-portland cement concrete (PCC) interfaces at 0, 100, 200 and 300 freeze-thaw cycles, with results shown in Appendix G.

Half-cell potential corrosion readings were taken approximately 13 months after overlay placement. Results are provided in Appendix B.

An additional 90-day chloride permeability test was performed on a 6-inch round wafer of the overlay that had been accidentally stripped off during an attempt to take a 6-inch diameter core. The test was accomplished by sealing a 9 1/2-inch long piece of 1 1/2" ID round PVC tubing to the top surface of the wafer and filling the tube full of an aqueous 3-percent NaCl solution. This test is further described in Appendix F, along with the results.

No further chloride content analyses of the overlaid concrete were made after the first year due to no deicing salf having been used on the bridge in the interiln. The first winter happened to be relatively mild.

6.0 Test Results

6.1 Chloride Content Reference Tests

The average reference chloride content per core segment in lbs of chlorides per CY of concrete for the northbound and southbound structures respectively, was as as follows:

	Northbound Structure Segment				Southbound Structure Segment			
Core	#1	#12	#3	#4	#1	#2	#3	#4
1	5.8	3.4	-8	.2		—	—	—
2	4.7	3.0	1.0	.8	—	—	—	—
3	5.0	3.4	2.3	1.2	—	—	—	—
4	5.9	2.7	.6	.4	—	—	—	—
Average	5.4	3.1	1.2	.65	—	—	—	—
5	—	—	—	—	3.7	1.2	.4	.1
6	—	—	—	—	2.4	.5	.3	.3
7	—	—	—	—	2.4	.5	.1	.1
8	—	—	—	—	5.0	3.6	.9	.4
Average	—	—	—	—	3.4	1.5	.40	.23

It may be noted that the .65 and .25 lbs/CY quantities at approximately the level of the top mat of reinforcing steel, and are well below the commonly accepted 2.0 lbs/CY threshold beyond which corrosion would probably be caused. (5)

Another observation is that the corrosion content of the northbound structure which was left uncovered, was found to have a much higher chloride content than the southbound structure that was overlaid. This difference amounted to about 183 percent at the top reinforcing steel level.

6.2 Half-Cell Potential Readings

All the half-cell potential readings, including those taken prior to placement of the overlay and those one year after overlay placement were all well below the commonly accepted -.35 volt threshold beyond which active corrosion of the reinforcing steel probably occurs. (5)

6.3 Skid Tests

The average of 5 skid measurements at 20, 30, 40 and 50 mph in each travel lane, both before and after overlay placement, were as follows:

Speed	Prior to Overlay			After Overlay		
Inside Lane	Outside Lane	Inside Lane	% Increase	Outside Lane	% Increase	
20	54	47	54	0	54	15
30	46	36	47	2	44	22
40	38	32	42	11	42	31
50	37	26	41	11	41	58

Significant increases in the skid resistance of the outside lane after overlay placement, were noted.

6.4 Corrosometer Probe Readings

Processing of the corrosometer probe readings yield the following average mils (.001 inch) per year (MPY) corrosion rates for both the overlaid structure and the adjacent uncovered northbound structure.

Probe	Overlaid Structure		Uncovered Structure	
	Avg. Change in Dial Reading %	MPY	Avg. Change in Dial Reading %	MPY
1	1.43	.0478	.857	.0287
2	3.43	.115	5.71	.191
3	1.57	.0525	2.71	.0906
4	3.29	.110	4.14	.138
Average	2.43	.0812	3.36	.112

The corrosion rates indicate some corrosion of the reinforcing steel is occurring in both structures. There is, however, an overall higher rate in the uncovered structure by approximately 38 percent. However, as noted in paragraph 6.1, the uncovered structure was found to have a higher chloride content to begin with by about 183 percent. Also, as noted in paragraph 6.1 there was more chloride content in the northbound structure initially.

6.5 Ponded Chloride Tests

The following tabulation shows for the overlaid (southbound) structure the average chloride content per ponded core segment, less the reference content from paragraph 6.1, to yield an apparent net chloride content that percolated through the overlay during the 90-day test period.

	Segment			
Core#	#1	#2	#3	#4
1	2.0	.2	.1	.2
2	2.7	.7	.1	.1
3	3.6	1.0	.3	.1
4	10.0	6.5	2.9	.4
Aug.	4.6	2.1	.85	.2
Less Avg. Reference C1 Content	5.4	3.1	1.2	.65
Apparent Net C1 Percolated Through Overlay (lbs/CY)	−.8	−1.0	−.35	−.45

As may be readily noted all the percolated chloride contents came out to be negative values. The apparent reason for this is the reference cores not being from the same vicinity of the deck as the cores used in the ponding tests. Results of the ponding tests therefore, cannot be evaluated at this time pending the taking and analyzing of appropriate additional reference cores. No deicing salt was issued on the bridge deck during the winter season after placement of the overlay.

6.6 Additional Chloride Ponding Test

From the data provided in Appendix F it may be determined that a total of 2.82 gm of 3-percent chloride solution permeated into the polymer concrete wafer during the 90-day test period. No determination was made of how much chloride was deposited on the bottom of the wafer. However, assuming one-half the solution did permeate to the bottom of the wafer and into an underlying bridge deck with a 2-inch reinforcing steel cover, it may then be calculated that a bridge deck under these conditions could be expected to receive an average additional chloride content of 1.23 lbs/CY down to the top mat of reinforcing steel.

6.7 Shear-Bond Strength Tests

Average concrete shear strengths and average shear strength of the overlay-concrete interface for 0, 50, 100 and 150 freeze-thaw cycles respectively, were as follows:

No. of	North Span		Middle Span		South Span		Av.	
Freeze-Thaw Cycles	Concrete Strength	Interface Strength	Concrete Strength	Interface Strength	Concrete Strength	Interface Strength	Conc. Strg.	Interface Strg.
0	872	1057	926	660	1327	660	1090	923
	926	990			1397	1246		
50	572	768	912	559	721	283	837	718
			889	943	1092	1037		
100	773	414	525	380	1094	414	789	392
	571	522	983	229				
150	572	414	882	205	660	492	774	467
	936	842	822	380				

The interface shear strength up to 50 freeze-thaw cycles appears to be comparable to the concrete shear strength but dropped off sharply at 100 and 150 cycles.

7.0 Costs

Cost data are not currently available.

8.0 Conclusions

1. Aside from the results of the "additional method" of testing the PC for permeability, no definite conclusions can be reached at this time on the effectiveness of the overlay as a barrier to moisture entering a bridge deck surface. Such conclusions are expected to be forthcoming after the taking and testing of additional reference cores for chloride content for comparison to content after the standard 90-day ponding test. Results from testing these additional cores should be valid since no deicing salt was used on the deck during the winter season after placement of the overlay.

2. Otherwise, the "additional method" test results demonstrate that the PC was pervious to the NaCl solution.

3. No conclusions can be drawn from the half-cell potential readings since they indicate no active corrosion was taking place either before the overlay or one year later.

4. The shear-bond strength tests indicate the overlay bond would remain adequate to develop the strength of the concrete up to 50 freeze-thaw cycles.

5. The skid tests demonstrate that a PC can significantly improve the skid resistance value of a deck wearing surface.

6. Cost data are not yet available.

9.0 References

1. "Polymer Concrete Overlays - Method B", Interim User Manual No. FHWA-TS-78-225, Federal Highway Administration, Washington, D. C., 1978, 21 pp.

2. Interoffice Memorandum From Ralph K. Banks to Files. Austin, Texas: Texas State Department of Highways and Public Transportation (SDHPT) Safety and Maintenance Operations Division, January 25, 1980, 2 pp.

3. Project Notes by Ronald P. Webster. Upton, N. Y.: Brookhaven National Laboratory, November 25, 1980, 4 pp.

4. Trip Report by Kenneth Hankins. Austin, Texas; Texas SDHPT Transportation Planning Division, October 30, 1980, 1 p.

5. Federal-Aid Highway Program - Manual - Volume 6-7-2-7, "Concrete Bridge Decks", Department of Transportation— FHWA, Washington, D. C., 1976, pp. 13-15.

6. Interoffice Memorandum from Fred Schindler to Files. Austin, Texas: Texas SDHPT, Materials and Tests Division, December 30, 1981, 2 pp.

COMMISSION
A. SAM WALDROP, CHAIRMAN
DEWITT C. GREER
RAY A. BARNHART

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
AUSTIN, TEXAS 78703

ENGINEER-DIRECTOR
M. G. GOODE

July 28, 1980

IN REPLY REFER TO
FILE NO. D-9-A

Subject: Concrete Bridge Deck Cores
County: Wichita
FCIP Study 1-30-80-542
Laboratory No. A80331456

Mr. Jimmy L. Stacks
District Engineer
District 3
Wichita Falls, Texas 76307

Dear Mr. Stacks:

The accompanying Laboratory Report A80331456 covers the results of the chloride tests made on eight cores from the Gilbert Creek Bridge in Wichita County. Compressive strength tests were not made.

Laboratory test charges are included on the report. If you desire more information on these cores, please let us know.

Sincerely yours,

M. G. Goode
Engineer-Director

By:

Kurn K. Moore
Acting Materials & Tests Engineer

BNB:bmd
Attach.

cc: File D-5

orm 231 - Rev. 6-79

Test Charge
Time and Expense = $676.00
Page 1 of 2

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION

GENERAL TEST REPORT

Contract/Reqn. No. ______ Control 542 No. ______
Engineer Jimmy L. Stacks Project FCIP Study 1-30-80 Hwy. US 281
Contractor ______ District 3 County Wichita

****

Laboratory No. A80331456
Date Sampled ______ Date Received 7-10-80 Date Reported 7-25-80
Material Concrete Bridge Deck Cores Code ______
Producer ______ Code ______
Identification Marks ______ Spec. Item ______
Sampled From ______ Quantity ______ Units ______

****

DETERMINATIONS

The water soluble chloride ion content was determined on segments of Eight cores taken from the deck of the Gilbert Creek bridge structure on U.S. 281 south bound lane. The top two inches of each core were cut into four- 1/2 inch nominal thickness segments using a diamond blade saw. Approximately 1/16 inch of each segment was lost during cutting.

Segments identification is as follows:

No. 1 - surface to 1/2 inch depth
No. 2 - 1/2 inch to 1 inch depth
No. 3 - 1 inch to 1 1/2 inch depth
No. 4 - 1 1/2 inch to 2 inch depth

The results are reported in terms of percent by weight and parts per million of chloride in each segment. The results are also presented in terms of pounds of chloride per cubic yard of concrete, based on an assumed density of 4000 pounds per cubic yard.

			Chloride Ion Content		
Sample I.D.	Segment No.	Actual Segment Measurement	%	ppm	lbs/cu.yd.
Core #1	1	3/8"	0.14	1,441	5.8
	2	7/16"	0.08	839	3.4
	3	7/16"	0.02	188	0.8
	4	1/2"	0.01	63	0.2
Core #2	1	7/16"	0.12	1,165	4.7
	2	7/16"	0.07	739	3.0
	3	*	0.02	238	1.0
	4	*	0.02	188	0.8

Form 231 - Rev. 6-79

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

GENERAL TEST REPORT

Contract/Reqn. No. ______ Control ______ No. ______
Engineer ______ Project FCIP Study 1-30-80-542 Hwy. US 281
Contractor ______ District 3 County Wichita

****

Laboratory No. A80331456
Date Sampled ______ Date Received ______ Date Reported ______
Material ______ Code ______
Producer ______ Code ______
Identification Marks ______ Spec. Item ______
Sampled From ______ Quantity ______ Units ______

****

Sample I.D.	Segment No.	Actual Segment Measurement	Chloride Ion Content %	ppm	lbs/cu.yd.
Core #3	1	*	0.12	1,240	5.0
	2	*	0.08	339	3.4
	3	*	0.06	564	2.3
	4	*	0.03	313	1.2
Core #4	1	*	0.15	1,466	5.9
	2	*	0.07	664	2.7
	3	*	0.01	138	0.6
	4	*	0.01	113	0.4
Core #5	1	7/16"	0.09	937	3.7
	2	3/8"	0.03	312	1.2
	3	1/2"	0.01	106	0.4
	4	1/2"	0.00	31	0.1
Core #6	1	3/8"	0.06	612	2.4
	2	3/8" to 7/16"	0.01	137	0.5
	3	7/16"	0.01	81	0.3
	4	3/8"	0.01	81	0.3
Core #7	1	3/8"	0.06	612	2.4
	2	3/8"	0.01	118	0.5
	3	7/16"	0.00	31	0.1
	4	7/16"	0.00	31	0.1
Core #8	1	3/8"	0.13	1,262	5.0
	2	3/8" to 7/16"	0.09	912	3.6
	3	7/16"	0.02	237	0.9
	4	1/2"	0.01	93	0.4

* Measurements were not obtained on these segments

July 23, 1980

Procedure for Determining Chloride Content in Concrete Cores

Equipment:

1. Mechanical Crushers and Grinding Machine
2. pH Meter
3. Selective Chloride Ion Electrode and Reference Electrode
4. 50 ml Pipette
5. 600 ml Beaker
6. 200 ml Tall Form Beaker
7. Analytical Balance
8. Number 60 Sieve
9. Hot Plate

Reagents:

1. 0.01 N Silver Nitrate
2. Methyl Red Indicator
3. 1:10 Nitric Acid

Sample Preparation:

The sample shall be crushed and ground to pass a #60 sieve and dried at 140 F oven for 24 hours. After the 24 hours, any iron in the sample from the grinder shall be removed with a magnet. Place the sample in a 140 F oven for 2-3 hours. Remove sample and cool.

Test Procedure:

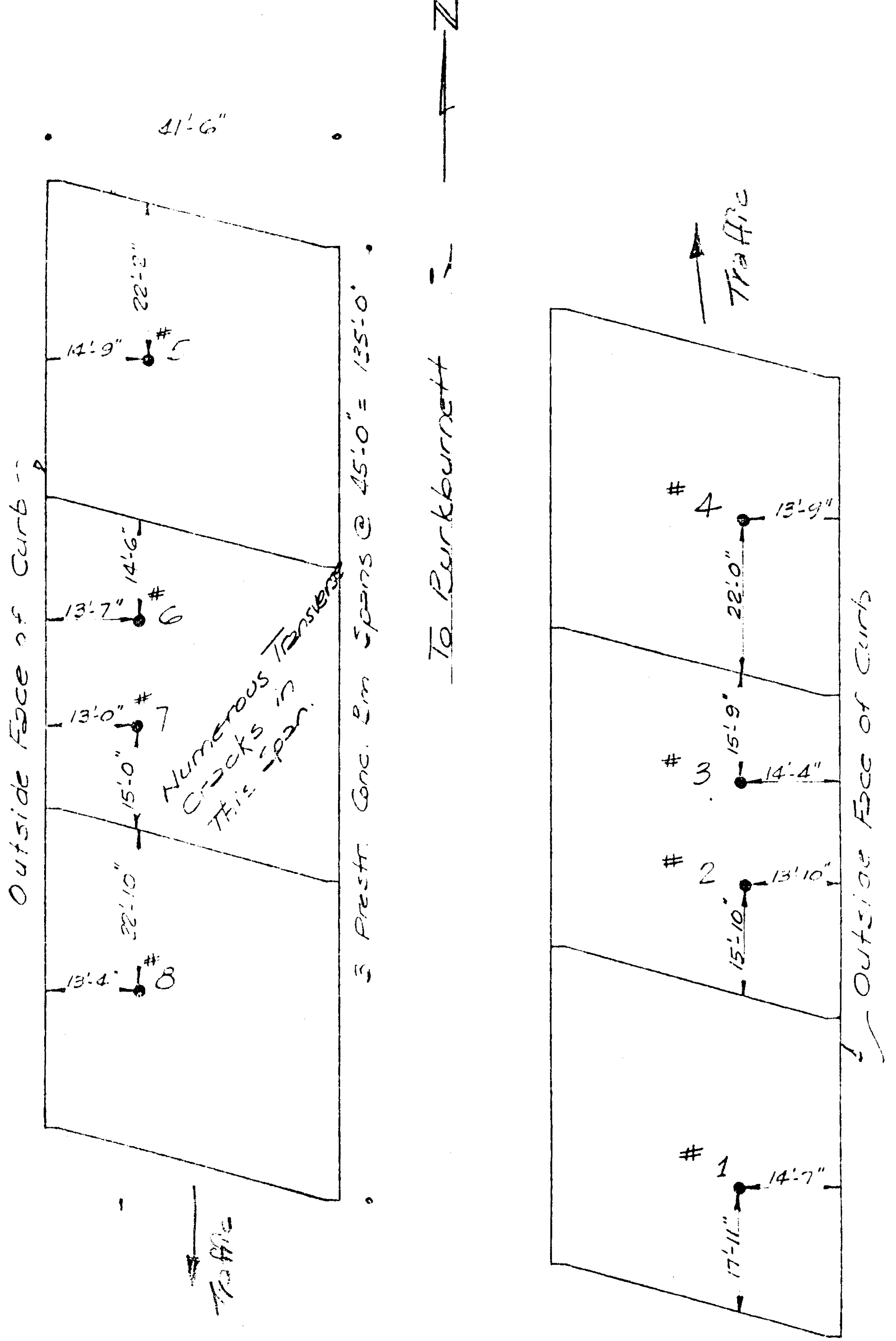
From the above prepared sample weigh out 30.0000 ± 0.01 grams into a 600 ml beaker. Add 300 ml distilled water and heat gently for 4 to 5 hours. Stir the sample periodically. Remove from heat and filter using No. 42 filter paper into a 500 ml volumetric flask. Allow solution to cool and bring solution up to mark on the volumetric flask using distilled water. Mix thoroughly.

Pipette a 50 ml sample from the volumetric flask into a 200 ml tall form beaker. Adjust pH of sample using Methyl Red Indicator to a light red color using weak Nitric Acid.

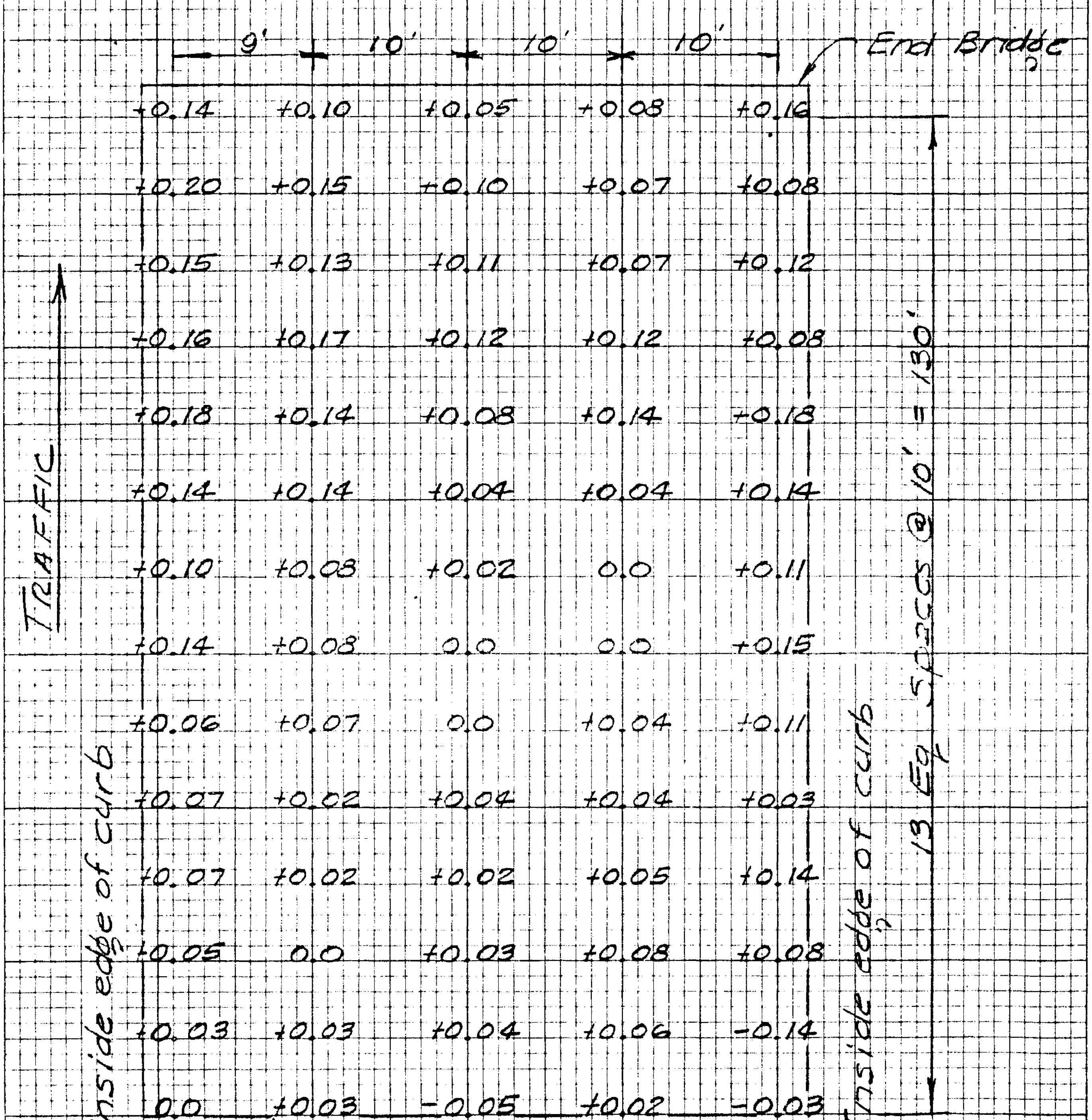
Using a selective Chloride Ion Electrode and Reference Electrode set pH meter on millivolt scale and titrate sample using 0.01 N Silver Nitrate solution. The end point will be the largest change in the millivolt reading.

Calculations:

$$\frac{(\text{mls of titrant})\ (\text{Factor for chloride } 3.5453)\ (\text{N of titrate})\ (\text{aliquot})}{\text{Sample Weight}}$$



U.S. 277 @ GILBERT CR.
Location of Cores

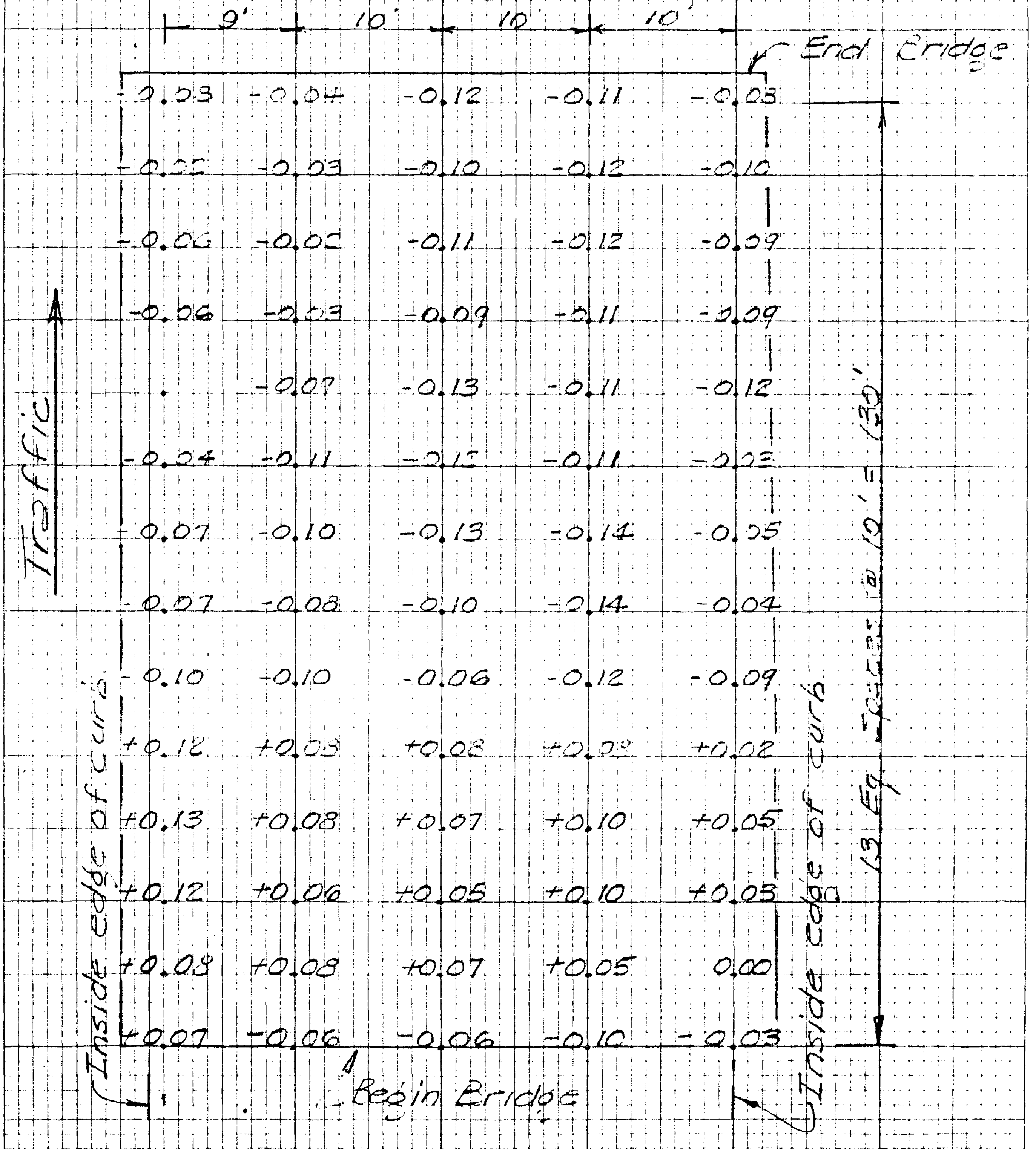


+0.14	+0.10	+0.05	+0.08	+0.16
+0.20	+0.15	+0.10	+0.07	+0.08
+0.15	+0.13	+0.11	+0.07	+0.12
+0.16	+0.17	+0.12	+0.12	+0.08
+0.18	+0.14	+0.08	+0.14	+0.18
+0.14	+0.14	+0.04	+0.04	+0.14
+0.10	+0.08	+0.02	0.0	+0.11
+0.14	+0.08	0.0	0.0	+0.15
+0.06	+0.07	0.0	+0.04	+0.11
+0.07	+0.02	+0.04	+0.04	+0.03
+0.07	+0.02	+0.02	+0.05	+0.14
+0.05	0.0	+0.03	+0.08	+0.08
+0.03	+0.03	+0.04	+0.06	-0.14
0.0	+0.03	-0.05	+0.02	-0.03

CORROSION POTENTIALS

US 77 SB @ GILBERT CREEK

10-16-80
HD Butler



-0.03	-0.04	-0.12	-0.11	-0.03
-0.05	-0.03	-0.10	-0.12	-0.10
-0.06	-0.05	-0.11	-0.12	-0.09
-0.06	-0.03	-0.09	-0.11	-0.09
	-0.07	-0.13	-0.11	-0.12
-0.04	-0.11	-0.13	-0.11	-0.03
-0.07	-0.10	-0.13	-0.14	-0.05
-0.07	-0.08	-0.10	-0.14	-0.04
-0.10	-0.10	-0.06	-0.12	-0.09
+0.12	+0.03	+0.08	+0.09	+0.02
+0.13	+0.08	+0.07	+0.10	+0.05
+0.12	+0.06	+0.05	+0.10	+0.03
+0.08	+0.08	+0.07	+0.05	0.00
+0.07	-0.06	-0.06	-0.10	-0.03

CORROSION POTENTIALS

US 177 SB @ [illegible] CREEK

12-3-81
HD Butler

COMMISSION
REAGAN HOUSTON, CHAIRMAN
DEWITT C. GREER
A. SAM WALDROP

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
Wichita Falls, Texas 76307

ENGINEER-DIRECTOR
B. L. DEBERRY

March 11, 1981

IN REPLY REFER TO
FILE NO.

Gilbert Creek Bridge

Austin Office
File D-18

Attention: Ralph Banks

Attached are the skid numbers for the Gilbert Creek Bridge polymer overlay which you requested. Give us a call if we can be of further assistance.

Sincerely yours,

Jimmy L. Stacks
District Engineer

By:
Frank S. Craig
District Construction Engineer

BP:ht
Attach.

LE 18.244

CO. 243 CONT. –
SECT. – STR. NO. –
REMARKS US 277 (SB)
Gilbert Creek
Bridge

TEXAS HIGHWAY DEPARTMENT
MAINTENANCE OPERATIONS DIVISION
ILLUSTRATION SHEET

REPORTER RWB
SECTION D-18M
DATE 3-25-80
SHEET 1 OF 1

SUMMARY OF SKID TESTS
(Prior to Overlay)

Speed (mph)	Lane	Reading 1	2	3	4	5	Average
20	A	50	55	53	56	55	54
	B	45	47	49	49	43	47
30	A	44	46	47	47	47	46
	B	33	36	36	39	35	36
40	A	39	37	39	38	—	38
	B	29	30	31	33	29	32
50	A	31	35	39	38	37	37
	B	24	27	—	26	27	26

Note:
The A-lane is the inside (median side).
The B-lane is the outside.

FILE 18.244

CO. 243 CONT. –
SECT. – STR. NO. –
REMARKS US 277(SB) Gilbert Creek Bridge

TEXAS HIGHWAY DEPARTMENT
MAINTENANCE OPERATIONS DIVISION
ILLUSTRATION SHEET

REPORTER RKB
SECTION D-18M
DATE 12-9-80
SHEET 1 OF 1

SUMMARY OF SKID TESTS
(After Overlay)

Speed (mph)	Lane	Reading 1	2	3	4	5	Averag
20	A	57	58	54	50	50	54
	B	50	58	56	53	51	54
30	A	46	45	46	47	49	47
	B	42	45	43	47	44	44
40	A	40	41	45	46	40	42
	B	42	42	40	42	42	42
50	A	42	41	39	41	41	41
	B	41	38	46	42	38	41

Note:
The A-lane is the inside (median side).
The B-lane is the outside.

COMMISSION
A. SAM WALDROP, CHAIRMAN
DEWITT C. GREER
RAY A. BARNHART

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
Wichita Falls, Texas 76307

ENGINEER-DIRECTOR
B. L. DEBERRY

December 8, 1981

IN REPLY REFER TO
FILE NO.

FCIP Study No. 1-3D-80-542
"Polymer Concrete Overlays"
(DOT-FH-11-8608, Task Order No. 18)

Austin Office
File D-18M

Attention: Ralph Banks

Enclosed are the corrosometer readings and probe diagrams which you requested on the above captioned project. No de-icing salts were applied to this structure last winter.

Sincerely yours,

Jimmy L. Stacks
District Engineer

By:
Frank S. Craig
Dist. Const. Engr.

/ht
Enc.

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 787

DATE INSTALLED: 10-80

LOCATION: Probe #1 SB Structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	787	147	BP
2	2-81	787	149	BP
3	3-81	787	147	BP
4	7-81	788	150	JH
5	8-81	788	150	JH
6	9-81	787	149	JH
7	10-81	785	147	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 796

DATE INSTALLED: 10-80

LOCATION: Probe #2 SB Structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	796	146	BP
2	2-81	796	144	BP
3	3-81	795	141	BP
4	7-81	796	142	JH
5	8-81	795	141	JH
6	9-81	797	143	JH
7	10-81	795	141	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 798

DATE INSTALLED: 10-80

LOCATION: Probe #3 SB structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	798	45	BP
2	2-81	800	46	BP
3	3-81	797	46	BP
4	7-81	797	48	JH
5	8-81	798	47	JH
6	9-81	796	43	JH
7	10-81	797	46	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 792

DATE INSTALLED: 10-80

LOCATION: Probe #1 SB structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	792	55	BP
2	2-81	792	51	BP
3	3-81	792	55	BP
4	7-81	793	49	JH
5	8-81	792	50	JH
6	9-81	792	49	JH
7	10-81	793	53	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 790

DATE INSTALLED: 10-30

LOCATION: Probe #1 NB Structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	790	127	BP
2	2-81	791	125	BP
3	3-81	791	127	BP
4	7-81	790	129	JH
5	8-81	790	128	JH
6	9-81	790	127	JH
7	10-81	792	126	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 829

DATE INSTALLED: 10-30

LOCATION: Probe #2 NB Structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	829	64	BP
2	2-81	827	52	BP
3	3-81	829	69	BP
4	7-81	829	58	JH
5	8-81	828	58	JH
6	9-81	829	60	JH
7	10-81	827	57	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 790

DATE INSTALLED: 10-80

LOCATION: Probe #3 NB Structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	790	116	BP
2	2-81	790	108	BP
3	3-81	791	110	BP
4	7-81	791	118	JH
5	8-81	790	118	JH
6	9-81	791	116	JH
7	10-81	790	115	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

MATCOR
CORROSOMETER® PROBE PR-CPBD-13
DATA SHEET

ORIGINAL CHECK READING: 788

DATE INSTALLED: 10-80

LOCATION: Probe #4 NB Structure

NOTE:

		A	B	
MONTH	DATE	CHECK READING	DIAL READING	READ BY
1	1-81	788	146	BP
2	2-81	789	149	BP
3	3-81	788	153	BP
4	7-81	788	148	JH
5	8-81	788	150	JH
6	9-81	789	152	JH
7	10-81	788	153	JH
8				
9				
10				
11				
12				
13				
14				
15				
16				

Copies To:

TECHNICAL MEMORANDUM

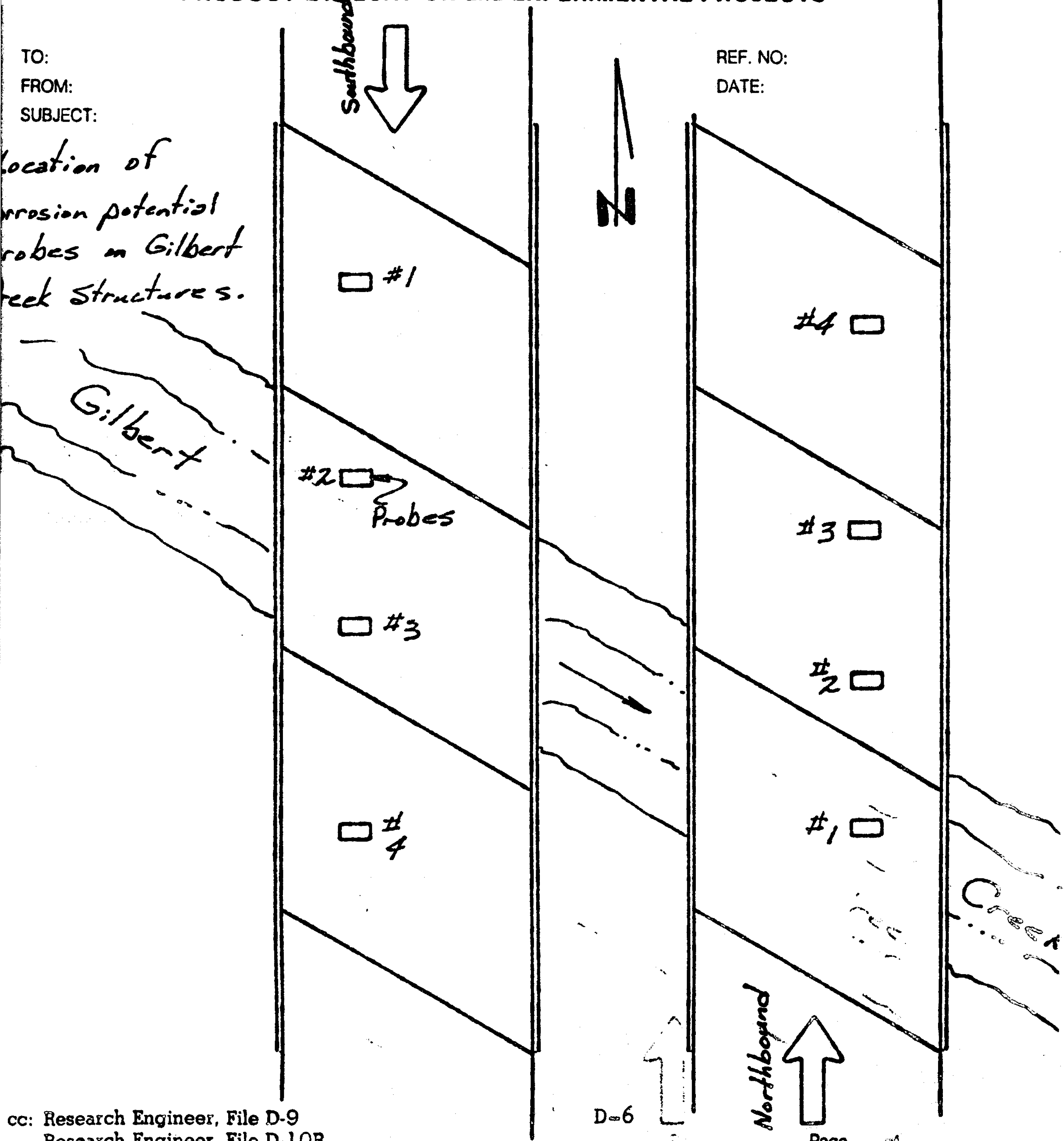
Texas State Department of Highways and Public Transportation

PRODUCT EVALUATION and EXPERIMENTAL PROJECTS

TO:
FROM:
SUBJECT:

REF. NO:
DATE:

location of
rrosion potential
robes on Gilbert
eek Structures.



cc: Research Engineer, File D-9
Research Engineer, File D-10R

D-6

Page of

Form 1378

MATCOR CORROSOMETER®
PR-CPBD-13

MEASURE ACTUAL BRIDGE DECK REBAR CORROSION RATES

OPERATION

The PR-CPBD-13 was developed for MATCOR, Inc. by the Magna Corporation especially for Bridge Decks and Highway structures. It is a compatible component of the MATCOR CPBD Bridge Deck Cathodic Protection System.

The PR-CPBD-13 Corrosometer® probe is placed into the same environment as the rebar. Therefore it will react to corrosion at the same rate as the rebar. The probe itself contains a reference element as well as the measuring element. The information accumulated by the probe is then read on the portable CK-3 instrument.

The CK-3 instrument compares the reference element with the measuring element and this information is used to calculate the rate of corrosion, in mils per year, of the rebar. Unlike using a direct resistance measurement, temperature changes do not affect the readings.

This probe with a 25 mil life is designed to provide the information required for evaluating actual bridge deck conditions.

APPLICATIONS

- **Cathodic Protection**

  measures effectiveness of the system.

- **Membranes**

  measure corrosion rate without damaging the seal.

- **Special Concrete Overlays**

- **Coated & Galvanized Rebars**

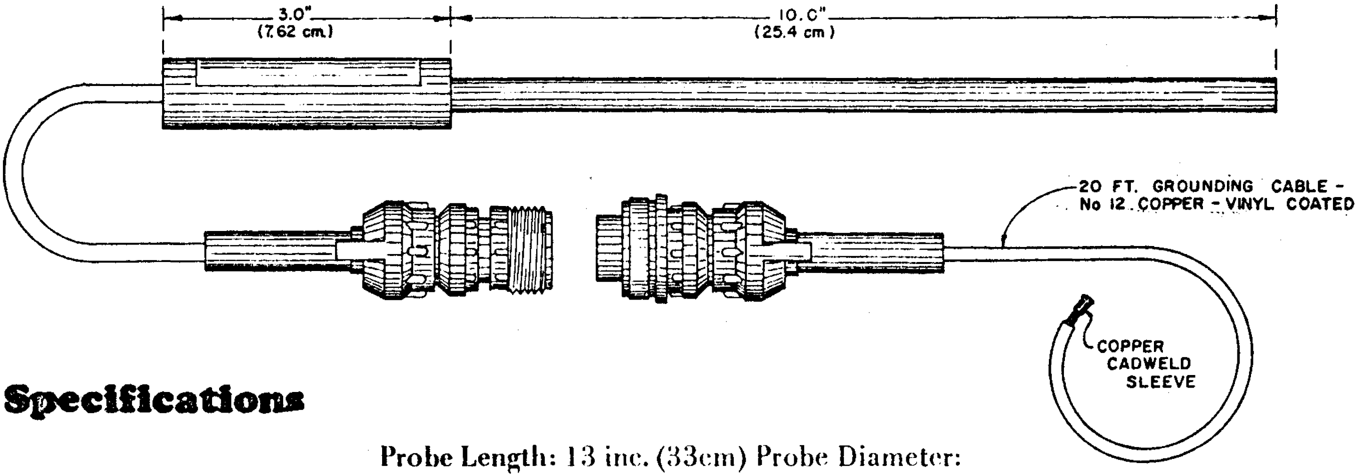
  As a comparison, the Corrosometer® will show what the rate of corrosion would be if the rebars were uncoated.

- **Non-Protected Decks**

  The Corrosometer® will assist in evaluating corrosion problems.

- **Pier Caps & Pilings**

TECHNICAL



Specifications

Probe Length: 13 inc. (33cm) Probe Diameter: .38 in. (9.65mm)
Cable Length (Grounding & Connector): 20 ft. (609cm) each
Probe Element Life: 25 mils
Probe Body Material: Glass Epoxy
Probe Fill Material: Epon 828 -Z Epoxy
Probe Temperature limits: -20°C to + 80°C
Probe Cable: Alpha 1320-10 Conductor, 22g. vinyl covered
Instrument Compatibility: Magna CK-3 Corrosometer set for 'Special'.
Note: Each probe is supplied with instruction and Data Sheets.

Ordering Codes

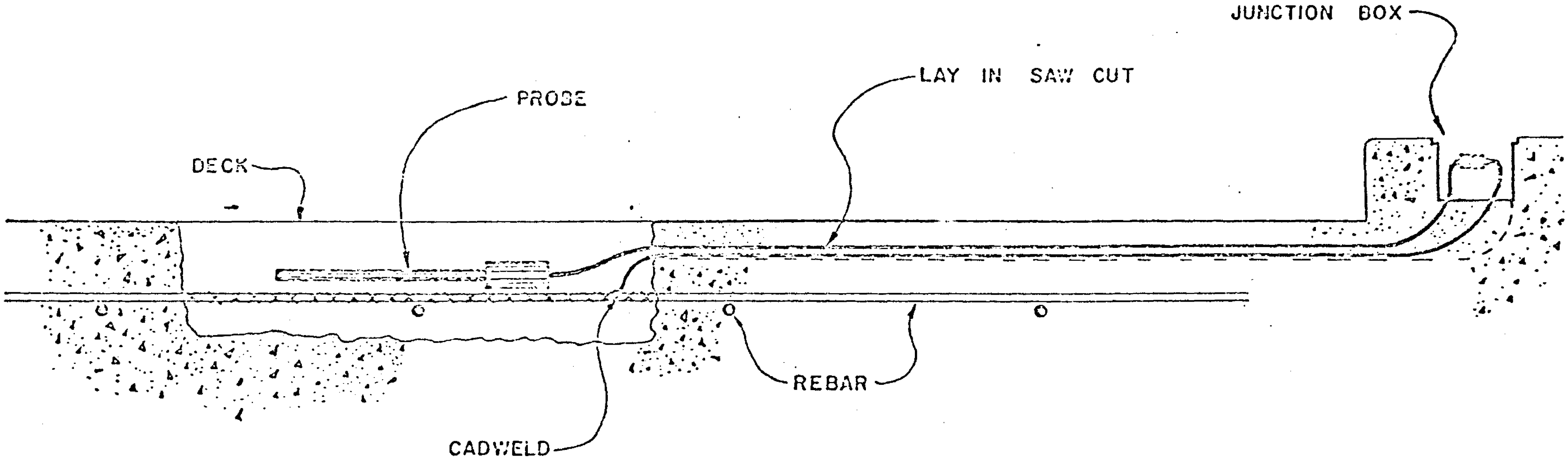
Basic Unit:	PR-CPBD-13
Connector Receptacle	PR-VB
Instrument - Portable Corrosometer	CK-3

Publications

Bulletin CPBD-8-75: Bridge Deck Cathodic Protection System
PR-CPBD-D: Data Sheet for Probe
PR-CPBD-1N: Installation Instructions for Probe
Bulletin 866: Corrosometer Theory
Bulletin 903: CK-3 Instrument

MATCOR, INC.

P.O. Box 687
Doylestown, Pa. 18901
Tel: (215) 348-2974
TWX: 510-665-8098



INSTALLATION

MATCOR PR-CPBD-13 CORROSOMETER^{R}

BRIDGE DECKS

1. Locate the probe as close as possible to the rebar without touching it.
2. Cadweld the green ground cable to the rebar.
3. Lay the ground cable and the control cable in the same saw cut.
4. Coil the plug and slack cable in the junction box or receptacle.
5. Fill the openings for the probe and cable with grout and/or concrete similar to the deck.

Note: It would be best if the fill material had the same chemical make-up as the original concrete, including chloride content.

6. The corrosometer is now ready to use.

MATCOR, INC.
P.O. Box 687
Doylestown, Pennsylvania 18901
(215) 348-2974

COMMISSION
A. SAM WALDROP, CHAIRMAN
DEWITT C. GREER
RAY A. BARNHART

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
AUSTIN, TEXAS 78703

ENGINEER-DIRECTOR
M. G. GOODE

December 22, 1981

IN REPLY REFER TO
FILE NO. D-9-A

Subject: Concrete Bridge Deck Chloride Tests
Project: FCIP 1-3D-80-542
County: Wichita
Laboratory Report #A81330557

Mr. Jimmy L. Stacks
District Engineer
District 3
Wichita Falls, Texas 76307

Dear Mr. Stacks:

The accompanying report covers 90 day chloride ponding and chloride analysis of four 4-inch diameter cores taken from the US 281-Gilbert Creek Southbound bridge structure for the subject project.

The cores with polymer concrete overlay seal were subjected to a solution of sodium chloride for 90 days to test for penetration into the concrete. The concrete was then analyzed for chloride content and the results are reported.

This information is being sent to File D-18 for their use and file.

Sincerely yours,

Billy R. Neeley

Billy R. Neeley /BRN
Materials & Tests Engineer

FAS:bmd
Attach.

cc: File D-18

COMMISSION

A. SAM WALDROP, CHAIRMAN
DEWITT C. GREER
RAY A. BARNHART

**STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION**
AUSTIN, TEXAS 78703

ENGINEER-DIRECTOR
M. G. GOODE

December 22, 1981

IN REPLY REFER TO
FILE NO. D-9-A

Subject: Concrete Bridge Deck Chloride Tests
Project: FCIP 1-3D-80-542
County: Wichita
Laboratory Report #A81330557

Mr. Jimmy L. Stacks
District Engineer
District 3
Wichita Falls, Texas 76307

Dear Mr. Stacks:

The accompanying report covers 90 day chloride ponding and chloride analysis of four 4-inch diameter cores taken from the US 281-Gilbert Creek Southbound bridge structure for the subject project.

The cores with polymer concrete overlay seal were subjected to a solution of sodium chloride for 90 days to test for penetration into the concrete. The concrete was then analyzed for chloride content and the results are reported.

This information is being sent to File D-18 for their use and file.

Sincerely yours,

Billy R. Neeley

Billy R. Neeley
Materials & Tests Engineer

FAS:bmd
Attach.

cc: File D-18

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION

GENERAL TEST REPORT

Contract Regn. No. ______ Control ______ No. ______
Engineer Jimmy L. Stacks Project FCIP 1-3D-80-542 Hwy US 281
Contractor ______ District 3 County Wichita

****

Laboratory No A81330557
Date Sampled 7-10-81 Date Received 7-14-81 Date Reported 12-21-81
Material Concrete Bridge Deck Cores Code ______
Producer ______ Code ______
Identification Marks #1 thru #4 Spec. Item ______
Sampled From Three Bridge Spans Quantity 4 Units Cores

****

Determinations

The water soluble chloride ion content was determined on segments of four cores taken from the deck of the US 281 Southbound lanes at Gilbert Cr. The top surface of the polym sealed cores was first subjected to 90 days of ponding with 3% solution of sodium chlorid and then sliced into 1/2 inch layers. The top two inches of each core were cut into four 1/2 inch nominal thickness segments using a diamond blade saw. Approximately 1/8 inch of each segment was lost during the cutting operation.

The results are reported in terms of percent by weight and parts per million of chloride in each segment. The results are also presented in terms of pounds of chloride per cubic yard of concrete based on an assumed density of 4000 pounds per cubic yard.

Core Locations on the bridge decks. (All cores taken a line 4'-0" from the outside face of the west curb.)

Core	Span #	Distance from North Edge of Slab Joint
1	1 (North)	5'-0"
2	2 (Middle)	5'-0"
3	2 (Middle)	20'-0"
4	3 (South)	12'-0"

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION

GENERAL TEST REPORT

[illegible] Room No. ______ Control ______ No. ______
Engineer ______ Project ______ Hwy. ______
Contractor ______ District ______ County ______

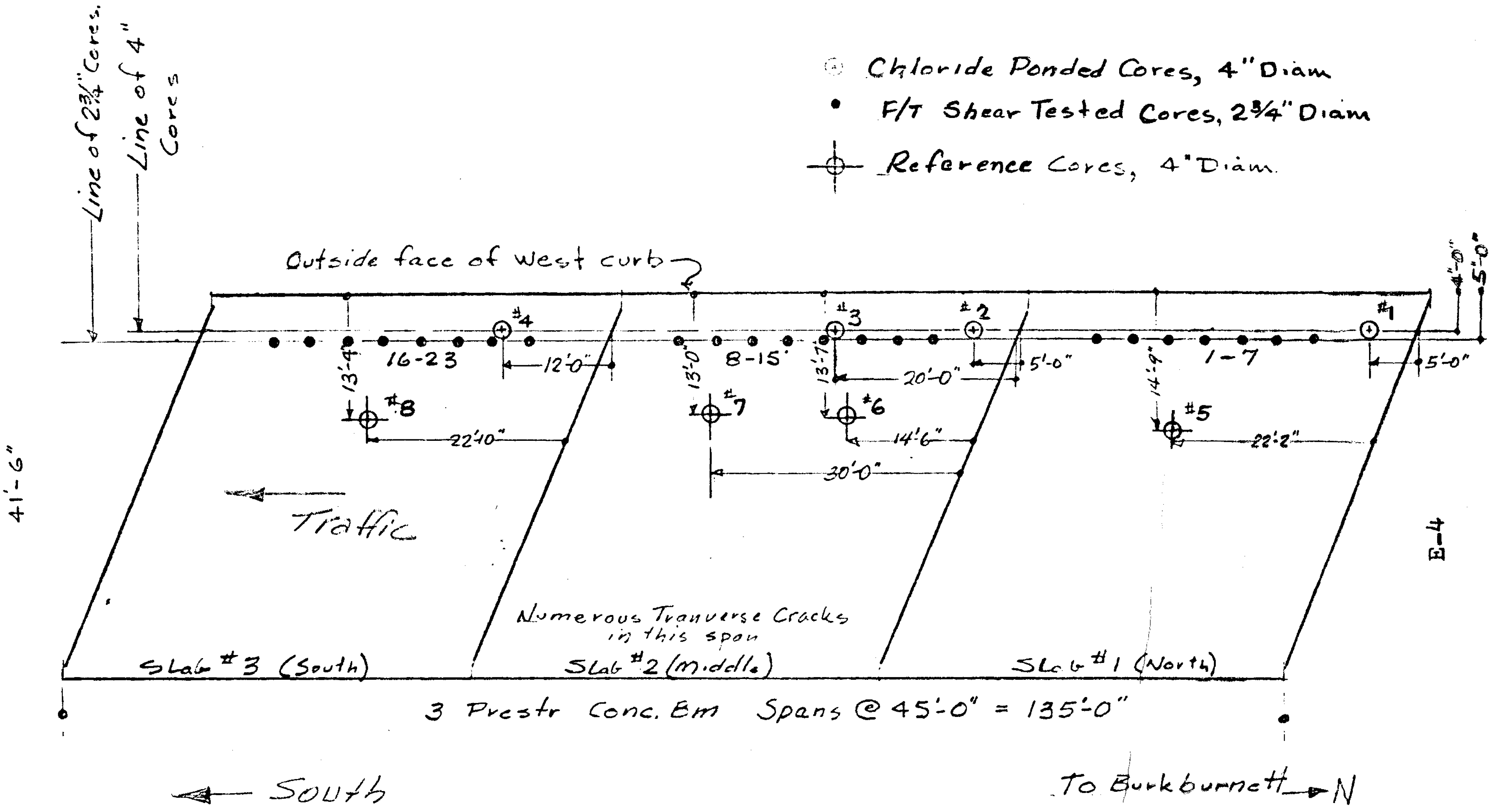
****

Lab Sample No. A81320557
Date Sampled ______ Date Received ______ Date Reported ______
Material ______ Code ______
Producer ______ Code ______
Identification Marks ______ Spec. Item ______
Sampled From ______ Quantity ______ Units ______

****

Chloride Analysis

Sample I.D.	Specimen No.	Actual Measurement	Chloride Ion Content %	ppm	lbs./cu.yd
Core #1	0" to 1/2"	7/8"	0.05	500	2.0
	1/2" to 1"	3/8"	0.01	55	0.2
	1" to 1 1/2"	3/8"	0.00	37	0.1
	1 1/2" to 2"	3/8"	0.01	61	0.2
Core #2	0" to 1/2"	7/8"	0.07	671	2.7
	1/2" to 1"	3/8"	0.02	183	0.7
	1" to 1 1/2"	3/8"	0.00	37	0.1
	1 1/2" to 2"	3/8"	0.00	37	0.1
Core #3	0" to 1/2"	7/8"	0.09	891	3.6
	1/2" to 1"	3/8"	0.02	256	1.0
	1" to 1 1/2"	3/8"	0.01	85	0.3
	1 1/2" to 2"	3/8"	0.00	37	0.1
Core #4	0" to 1/2"	7/8"	0.25	2,501	10.0
	1/2" to 1"	3/8"	0.16	1,623	6.5
	1" to 1 1/2"	3/8"	0.07	720	2.9
	1 1/2" to 2"	3/8"	0.01	110	0.4



Southbound Structure

US. 287 @ Gilbert Cr.

LOCATION of CORES

12-30-81

TO: Ralph K. Banks, Safety & Maint. Opns. Div.

FROM: Fred Schindler, Materials & Tests Div.

SUBJECT: TEST FOR PERMEABILITY OF POLYMER CONCRETE SEAL

This method was devised to determine the permeability of sodium chloride solution into the surface of polymer concrete.

Description of the test:

A 6-inch diameter core of the polymer concrete seal was subjected to 90 days of an aqueous solution of 3 percent NaCl under approximately 9 1/2 inches of hydraulic head (the level of solution was allowed to drop without replenishment).

The apparatus was made up of a 1 1/2 inch inside diameter (Sch 40 PVC) pipe (Figure 1) 9 1/2 inches long, glued to the surface of the specimen. The specimen was supported at three points on its periphery and open to the atmosphere on all surfaces (except where it was glued to the pipe). The top of the pipe was covered with a 2 1/2 inch diameter watch glass, which allowed normal vapor pressure on the solution.

Results of 90-day tests:

The solution was absorbed into the polymer concrete seal at a constant rate of 0.11 grams per day (exposed area = 1.767 sq in.) for the first 13 days and then had a constant rate of 0.018 grams per day for the remainder of the test period. Sodium chloride crystals (Figure 2) appeared on the top surface, at the outside edge and on the bottom surface of the specimen. This test demonstrated that the polymer concrete seal was pervious to the solution of sodium chloride.

SUBJECT: Set-up For Test for Permeability of Polymer Concrete Overlay

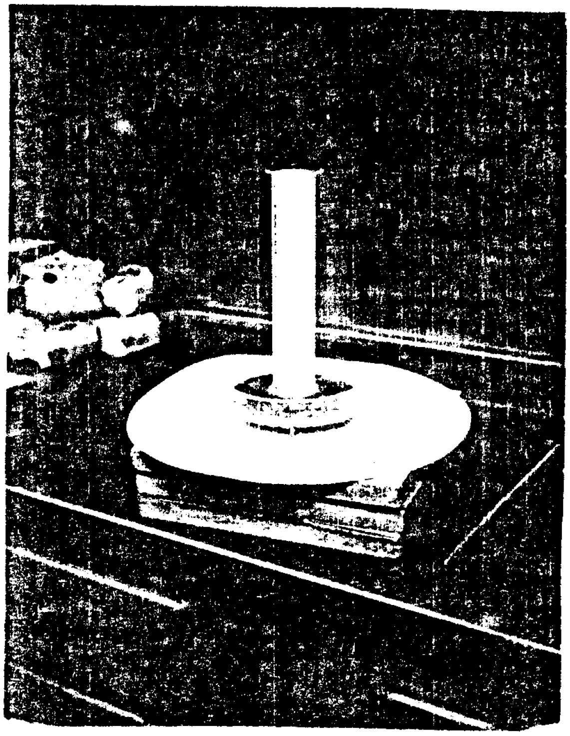


Figure 1

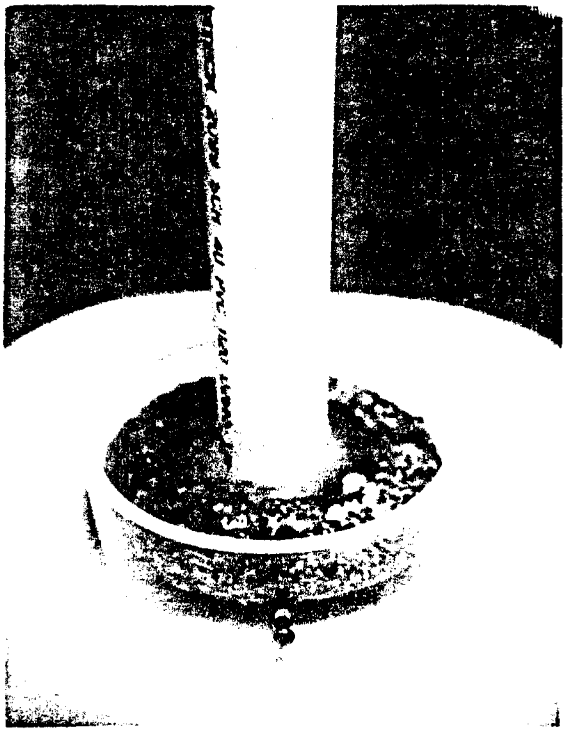


Figure 2

[illegible] A

Form 433-B

INTEROFFICE MEMORANDUM

O:	Mr. Donald L. O'Connor	**Date**	July 14, 1981
ROM:	Billy N. Banister	**Responsible**	
UBJECT:	Shear-Bond Strength Test Results Research Project 3-03-80-097, "Polymer Concrete Overlay"	**Desk**	D-9-A

The accompanying test data covers laboratory determinations made on twenty 2-3/4" cores submitted from subject bridge. The cores were subjected to freeze-thaw cycles as described in ASTM C 666 Procedure B.

The bond-shear tests were made on the seal coat concrete interface and on the parent concrete using apparatus submitted from District 3.

The results show an overall trend of loss in strength as the number of freeze-thaw cycles are increased. The bond-shear strength at the interface of the seal coat and concrete appears to be affected by the porosity of the concrete. The middle span cores appeared to have higher density and allowed less penetration of seal. This caused the seal to split away cleanly from the concrete.

FAS:bmd
Attach.

Billy N. Banister

TEST DATA

Concrete Core-Seal Coat Shear Bond Tests

Determinations: To determine the effect of freezing and thawing on the bond of the seal coat to the concrete with a test jig from FHWA.

a. Core Location and Ideitification

1. Bridge Structure: US 277 & 281 Southbound
   Structure (outside lane) over Gilbert Creek
   (see attached drawing)

Core #1 through #7	north span
#8 through #15	middle span (Core #12 missing)
#16 through #21	south span

All cores taken approximately 5' from face of west curb.

b. Core Conditioning

1. Cores from each span were tested for shear-bond strength as received both at the concrete-seal coat surface and through the parent concrete.

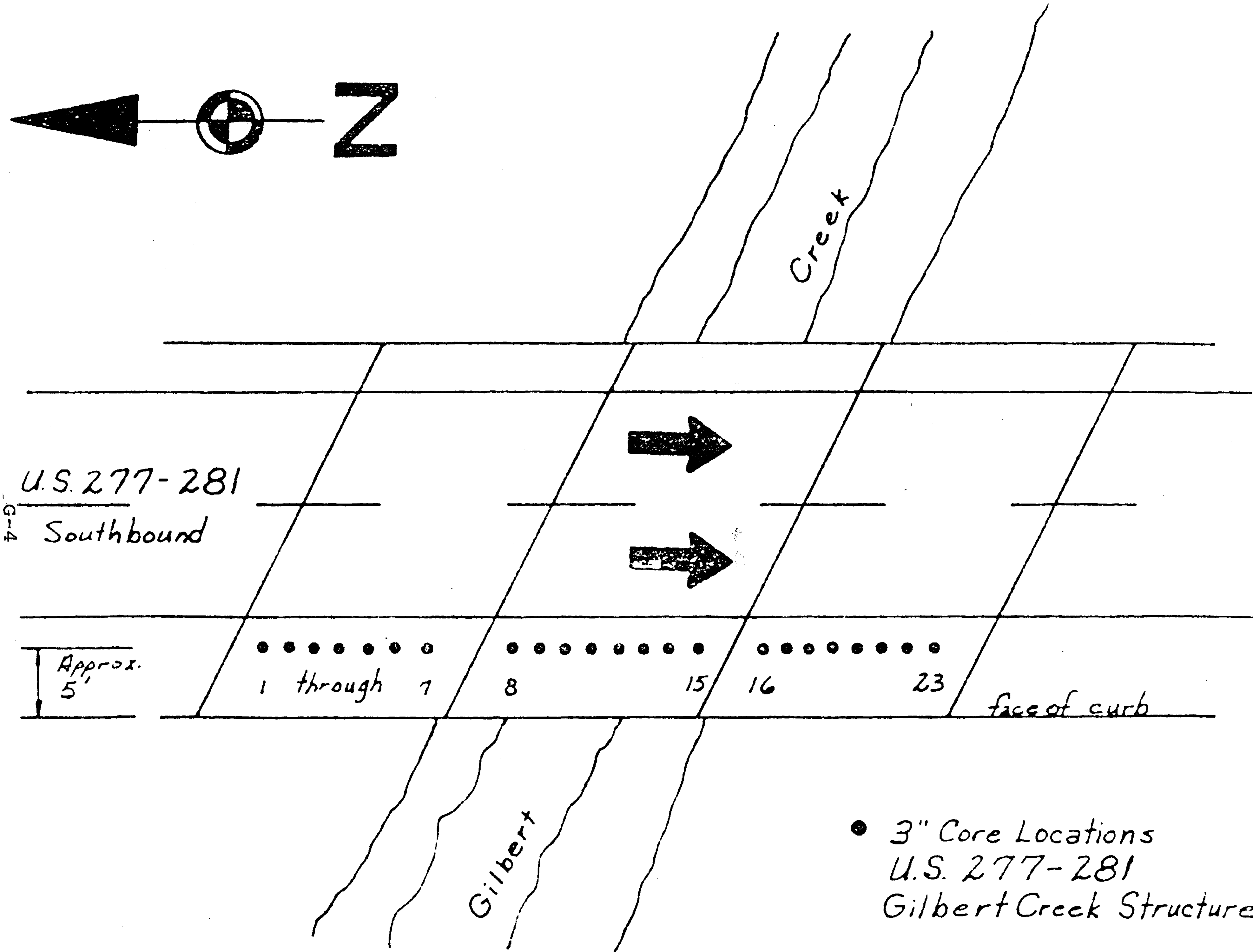
2. Cores from each span were subjected to ASTM C 666 freezing in air and thawing in water and tested at 50, 100 and 150 cycles before bond-shear tests.

3. Test Loading rate was at 20 psi per second.

c. Shear-Bond Test Results on 2-3/4" Diameter Cores With Approximately 1/2" Polymer Seal. The test data shows two types of fracture in the bond-shear testing; 1 = diagonal splitting in the parent concrete and 2 = seal coat splitting away from the concrete surface. The approximate percentage of area of bond-shear failure is also shown.

Bond-Shear Strength, PSI

North Span				Fracture Description		
No. of F/T Cycles	Concrete	Concrete-Seal Coat	Type	% Concrete	% Interface	% Seal-Coat
0	Core #1 = 872	1057	1	30	50	20
	Core #2 = 926	990	1	80	--	20
50	Core #3 = 572	768	1	20	60	20
100	Core #4 = 773	414	1	80	10	10
	Core #5 = 571	522	1	90	10	0
150	Core #6 = 572	414	1	0	100	0
	Core #7 = 936	842	1	50	50	0
Middle Span						
0	Core #8 = 926	660	2	0	100	0
50	Core #9 = 912	559	2	0	100	0
	Core #10 = 889	943	2	0	100	0
100	Core #11 = 525	380	2	0	100	0
	Core #13 = 983	229	2	0	100	0
150	Core #14 = 882	205	2	0	100	0
	Core #15 = 822	380	1	20	80	0
South Span						
0	Core #16 = 1327	660	1	70	30	0
	Core #17 = 1397	1246	1	90	10	0
50	Core #18 = 721	283	2	0	100	0
	Core #19 = 1092	1037	1	30	70	0
100	Core #20 = 1094	414	1	50	50	0
150	Core #21 = 660	492	2	0	100	0



● 3" Core Locations
U.S. 277-281
Gilbert Creek Structure