Donohue

FINAL REPORT

EVALUATION OF BOND RETAINAGE

IN

PORTLAND CEMENT CONCRETE OVERLAYS

USING

INFRARED THERMOGRAPHY

AND

GROUND PENETRATING RADAR

FOR THE

IOWA DEPARTMENT OF TRANSPORTATION

Engineers & Architects

FINAL REPORT

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IN
PORTLAND CEMENT CONCRETE OVERLAYS
BY
INFRARED THERMOGRAPHY
AND
GROUND PENETRATING RADAR

FOR THE

IOWA DEPARTMENT OF TRANSPORTATION

BRICE PETRIDES-DONOHUE
ENGINEERS & ARCHITECTS

PROJECT NO. 50389

Brice, Petrides • Donohue

June 28, 1989

Iowa Department of Transportation
800 Lincoln Way
Ames, Iowa 50010

Attn: Mr. Roman Dankebar
Office of Transportation Research
Planning and Research Division

Re: Evaluation of Bond Retainage in
Portland Cement Overlays
Donohue Project No. 50389

Dear Mr. Dankebar:

We are respectifully submiting our revised final report which summarizes the results of the evaluation of bond retention in Portland Cement Overlays. The evaluation was performed utilizing Infrared Thermography and Ground Penetrating Radar. The report, in addition to identifying areas of debonding, provides a discussion of equipment and procedures utilized during this project.

Following your review of this report, we would be pleased to discuss the material contained herein.

Very truly yours,

DONOHUE & ASSOCIATES, INC.

Jerry W. Eales

Jerry W. Eales, P.E.
Remote Sensing Manager

Daniel D. Ulrikson

Daniel D. Ulrikson, P.E.
Project Manager

cc: Dick King

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

CHAPTER 1

INTRODUCTION

BACKGROUND

When concrete deterioration begins to occur in highway pavement, repairs become necessary to assure the rider safety, extend its useful life and restore its riding qualities. One rehabilitation technique used to restore the pavement to acceptable highway standards is to apply a thin portland cement concrete (PCC) overlay to the existing pavement. First, any necessary repairs are made to the existing pavement, the surface is then prepared, and the PCC overlay is applied.

Brice Petrides-Donohue, Inc. (Donohue) was retained by the Iowa Department of Transportation (IDOT) to evaluate the present condition with respect to debonding of the PCC overlay at fifteen sites on Interstate 80 and State Highway 141 throughout the State of Iowa. This was accomplished by conducting an infrared thermographic and ground penetrating radar survey of these sites which were selected by the Iowa Department of Transportation. The fifteen selected sites were all two lanes wide and one-tenth of a mile long, for a total of three lane miles or 190,080 square feet. The selected sites are as follows: On Interstate 80 Eastbound, from milepost 35.25 to 35.35, milepost 36.00 to 36.10, milepost 37.00 to 37.10, milepost 38.00 to 38.10 and milepost 39.00 to 39.10, on State Highway 141 from milepost 134.00 to 134.10, milepost 134.90 to milepost 135.00, milepost 135.90 to 136.00, milepost 137.00 to 137.10 and milepost 138.00 to 138.10, and on Interstate 80 Westbound from milepost 184.00 to 184.10, milepost 185.00 to 185.10, milepost 186.00 to 186.10, milepost 187.00 to 187.10, and from milepost 188.00 to 188.10.

PURPOSE

The purpose of this project was to evaluate the location and quantities of debonding in the selected portland cement concrete (PCC) overlays.

SCOPE

The project entailed an infrared thermographic survey and a ground penetrating radar survey of the PCC overlays to locate areas of debonding between the overlays and the original pavement. An infrared scanner is capable of locating these areas because of the temperature differential which is established between bonded and debonded areas under certain environmental conditions. A conventional video inspection of the top surface of the pavement was also completed in conjunction with the infrared thermographic survey to record the visual condition of the pavement surface. The ground penetrating radar system is capable of locating areas of debonding by detecting return wave forms generated by changes in the dielectric properties at the PCC overlay original pavement interface.

This report consists of two parts; a text and a set of plan sheets. The text summarizes the procedures, analyses and conclusions of the investigation. The plan sheets locate specific areas of debonding, as identified through field observations.

DEFINITIONS AND ABBREVIATIONS

The following definitions and abbreviations appear throughout the report.

debonding	-	A separation of the portland cement concrete overlay from the original pavement.
Donohue	-	Brice Petrides-Donohue, Inc.
GPR	-	Ground Penetrating Radar
PCC	-	Portland cement concrete
Strip Chart	-	A graphic representation of the radar signal wave form.

ACKNOWLEDGEMENTS

IOWA DEPARTMENT OF TRANSPORTATION

Bill M. McCall, P.E.
Director of Transportation Research

Roman Dankebar
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Daniel D. Ulrikson, P.E.
Project Manager

GROUND PENETRATING RADAR

CHAPTER 2

GROUND PENETRATING RADAR

INTRODUCTION

The use of remote sensing techniques for non-destructive testing of pavement structures has become increasingly attractive in recent years as these techniques have become more sophisticated, reliable and accurate. Thermal infrared scanners, falling weight deflectometers, ground penetrating radar, and other techniques have become important to assist street and highway engineers in determining existing pavement condition, planning repair strategies, predicting remaining pavement life, and making repair versus replacement decisions.

The particular pavement defect of interest for this study involves the debonding of the portland cement concrete (PCC) overlay from the original pavement.

EQUIPMENT

Ground penetrating surface interface radar is a non-destructive remote sensing system that can be used to rapidly identify and evaluate various pavement structure conditions. This equipment can be used to measure pavement thickness, identify thin, weakened areas, locate voids beneath the pavement caused by settlement or pumping of subbase material, identify pavement deterioration/debonding, deterioration at joints and random cracks, measure overlay thickness, and determine the position of reinforcing steel within the slab. This technique is applicable to streets and highways, bridge decks, airport runways, and other pavements.

The equipment utilized for these investigations was a SIR System-8 manufactured by Geophysical Survey Systems, Inc. The system consists of a control unit, transducer (radar transmitter, receiver and antenna), a graphic chart recorder, and a magnetic tape recorder. The equipment operates on 12 volts DC which is obtained from the electrical system of the vehicle used for data collection.

Radar transducers operating at different frequencies and wave lengths can be used with this equipment. In general, lower transducer frequencies will yield greater depth of penetration of the radar signal, while higher frequencies, although not able to penetrate the earth as deeply, give the greatest resolution. This greater resolution gives the high frequency transducer the ability to discriminate between closely-spaced objects and interfaces. The antenna used for pavement evaluation operates at a center frequency of one GHz (1×10^9 Hz). This transducer yields the best near surface resolution while still providing adequate depth penetration for purposes of pavement structure evaluation.

In operation, a brief pulse of electromagnetic energy, 0.8 nanoseconds long (0.8×10^{-9} seconds) is directed into the pavement. When this energy encounters an interface between two materials of differing dielectric properties, a portion of the energy is reflected back to the transducer. The reflected energy is received by the transducer and processed within the control unit where it is amplified and the time differential between initial transmission of the electromagnetic pulse and the reception of the reflected wave is determined. The electromagnetic wave travels through the medium at a velocity dependent upon its dielectric characteristics, so the time differential can be converted into depth. This requires knowledge of the dielectric constant of the medium or, more commonly, on-site determination of the depth of a visible radar target. For pavement evaluation studies, this is commonly accomplished by taking several test cores for calibration. The electromagnetic pulse is repeated at a rate of 50 KHz (50 x 10^3 Hz), and the resultant stream of radar data is sent to the chart recorder where a continuous hard copy of the data is produced, and to the magnetic tape recorder where the individual radar wave forms are recorded.

At the control unit, the operator has an oscilloscope display upon which the reflected wave form can be continuously monitored. Controls are also available to enable the operator to adjust and optimize the output on the graphic chart recorder.

PROCEDURES

The GPR transducers were mounted on a bar extending from the front of the data collection van, Figure 1. The oscillographic reproduction of the radar wave form and the graphic representation produced by the strip chart recorder were continuously monitored and optimized by the operator in the van, Figure 2. The speed of the data collection van was held to approximately 2 miles per hour along the path selected.

Horizontal control for all of the locations was established by distance measuring equipment in the data collection van. This control was tied to physical features at each site. During the data collection phase the distance measuring equipment automatically placed footage markers on the strip chart. This horizontal referencing allowed accurate location of problem areas during the analysis of the data.

FIGURE 1

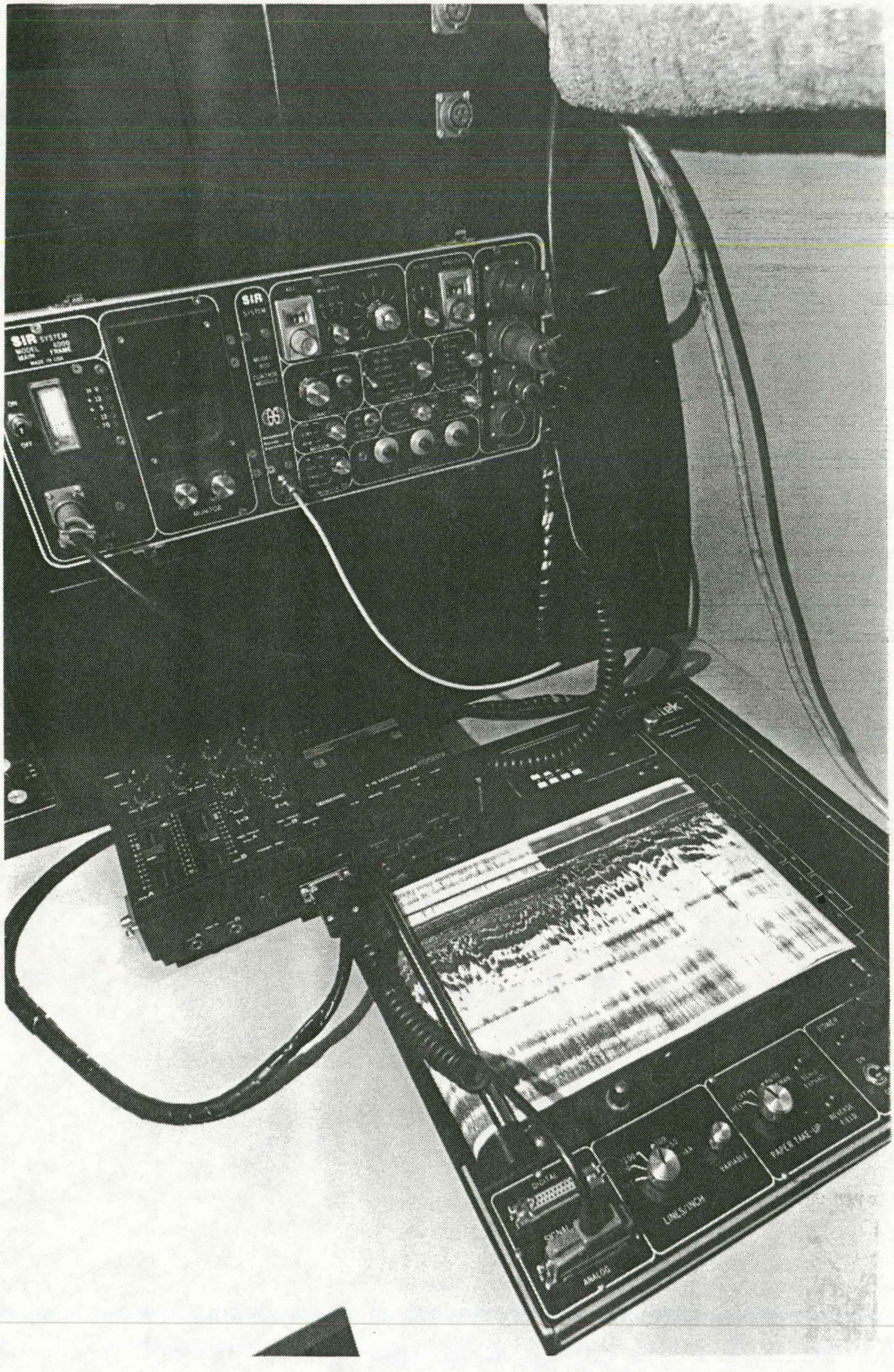
SIR SYSTEM
SIR
LINES/INCH
PAPER TAKE-UP
ANALOG
DIGITAL
SIGNAL
VARIABLE

FIGURE 2

The data collection was conducted from August 18-20th, 1987 and from August 9-11th, 1988. At these times, three longitudinal data collection passes were made in each lane using the dual transducers. This resulted in longitudinal data lines two feet apart over the entire width of the test sections which were selected by the Iowa Department of Transportation for this project. A specific description of these sites can be found in Chapter 1 of this report under the heading "Background".

After the scans were completed a preliminary analysis of the data was done in order to select locations for coring. A total of ten cores in 1987 and ten cores in 1988 were taken for the purpose of ground penetrating radar calibration. The location of these cores along with three cores taken in 1987 and two cores in 1988 for the purpose of infrared verification can be found on the planviews at the end of this report (Appendix B). The criteria used for selection of the truthing and calibration cores are discussed in the Results Section of this report.

ANALYSIS

The analysis of the GPR data focused on the signature of the interface between the original pavement and PCC overlay. Analysis of this interface was done with respect to amplitude or frequency changes, degradation of return signal or a scattering of the return signal. These changes in the interface signature are caused by changes in the dielectric properties occurring at the interface. For a debonding condition to be detectable with GPR, the dielectric properties of the interface between the original pavement and PCC overlay must change. This change would be caused by the debond creating an air gap, thereby producing a dielectric difference at the interface.

Previous work by Donohue and others (Chung, Carter, et al, 1984) indicated that at areas where debonds are present, a distinctive signature will appear on the GPR data. This distinctive signature is the result of interference with propagation of the GPR signal through the pavement caused by the very small air gap present at the debonded interface. Figure 3 is an example of a gray scale chart showing the signature obtained from a debonded portland cement overlay on a previous Donohue project.

For many pavement defects such as voids, joint deterioration misaligned reinforcing steel, etc., identification with the GPR system is dependent on receiving a definite reflection of the radar signal from the defect of interest. For debonding, however, the air gap at the interface of the overlay and underlying pavement is almost always too small to produce a distinct reflection that can be analyzed. However, the discontinuity in the composite slab present at debonded areas, which may be extremely thin, causes changes in the signal waveform that are detectable with the system.

Comparisons between the data collected in 1987 and that collected in 1988 were made to assure that the results were repeatable. It was found that anomalies identified in 1987 were repeated in the data collected in 1988. Further, the horizontal position of the anomalies were checked to verify the accuracy of the distance measuring device. Figure 4 is an example of GPR charts from the same test section generated in the two years. Minor variations in the signatures are the result of slightly different equipment settings between the two surveys.

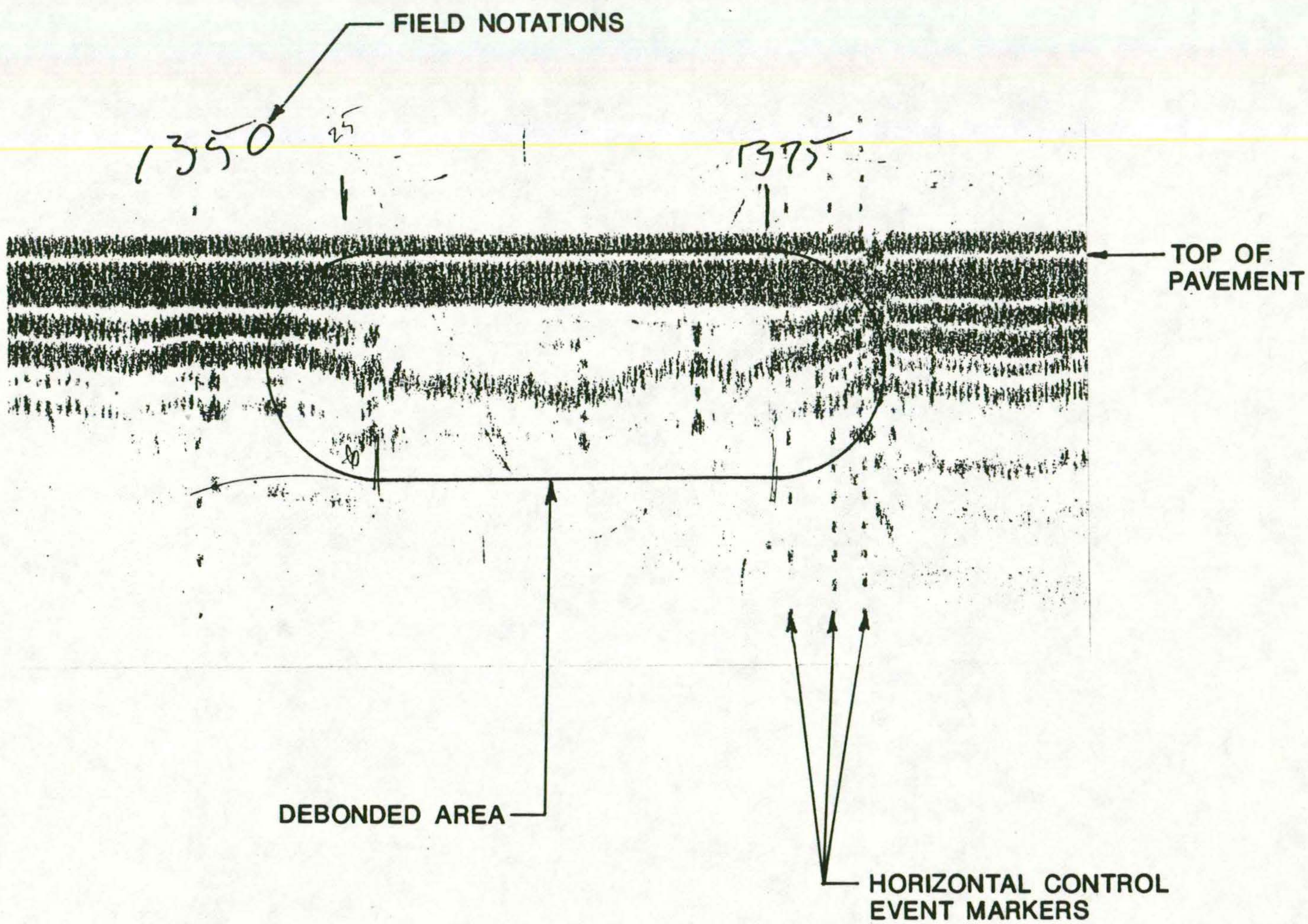

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FIGURE 3
SAMPLE OF GPR CHART SHOWING DEBONDED CONDITION
(FROM PREVIOUS DONOHUE PROJECT)

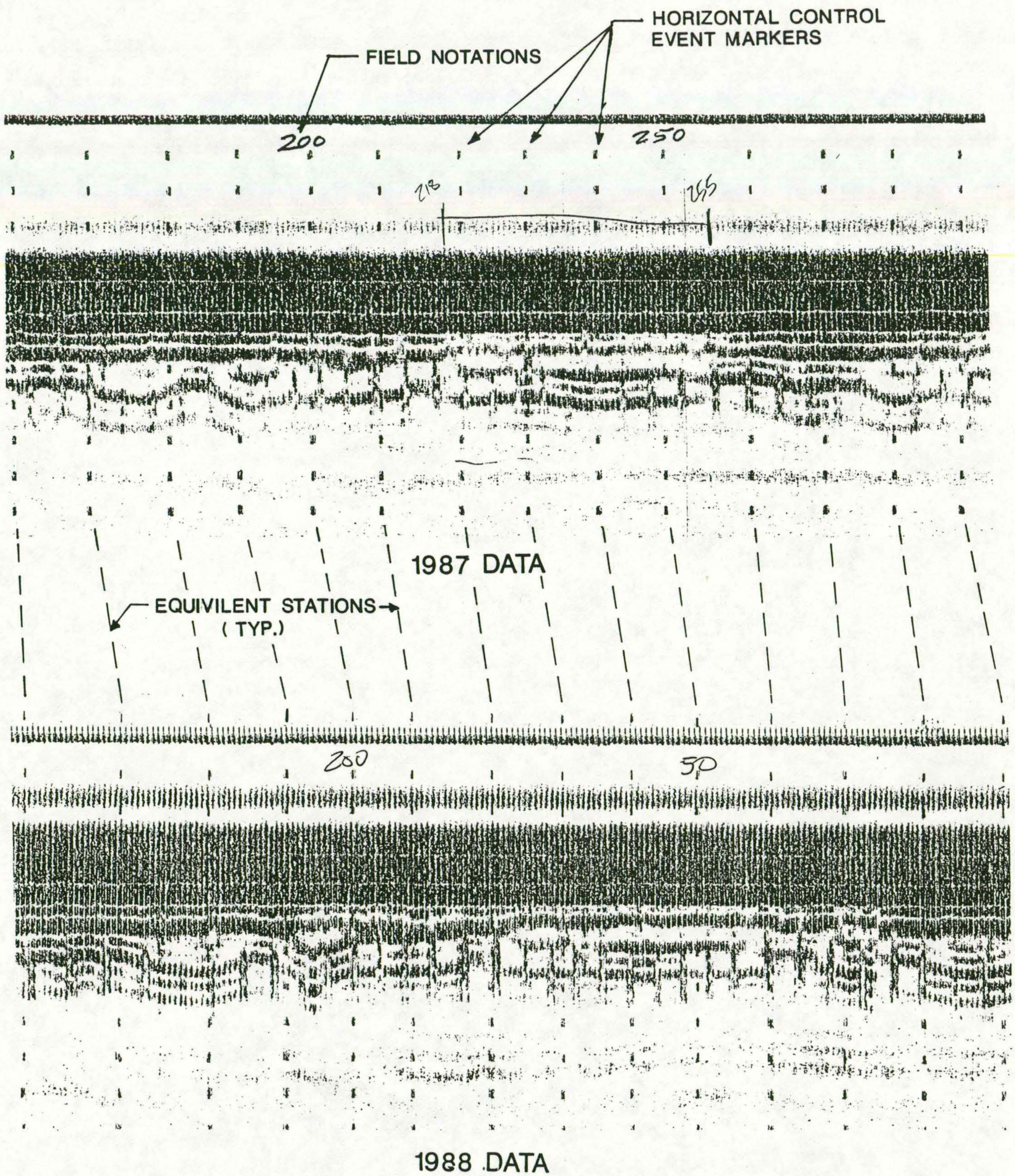

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FIGURE 4

SAMPLE GPR CHARTS SHOWING
COMPARATIVE DATA - 1987 AND 1988 DATA
I 80 EB MP. LEFT TRANSDUCER

RESULTS

The locations for calibration and truthing cores were selected at areas where the GPR signatures exhibited a pattern similar to that shown in Figure 3. There were no instances of signatures as definitive as the example shown but several that were close in their characteristics were investigated. The following paragraphs discuss the results of the data analysis and coring.

A total of eleven cores were taken in the five test sections between mileposts 35.25 and 39.10 on Interstate 80 eastbound. Cores were selected both in areas where debonding was suspected and in areas where the pavement/overlay appeared sound. All six of the cores taken in 1988 at areas of suspected debonding (Nos. 1, 2, 3, 4, 5 and 6) and four of the five cores taken in 1987 at areas exhibiting similar signatures (Nos. 2, 3, 4, and 5) were either broken during coring or broken when handled. Detailed descriptions of the cores can be found in Appendix A. While no debond condition was present, the cores broke easily, with light finger pressure, just below the interface between the original pavement and PCC overlay. We feel that these cores are representative of a weak concrete which is a preface to an early stage of deterioration where small fractures begin to occur. This is a condition that can be related to the degradation of the interface signature seen at various locations in these same sections (Figure 5). At two locations between mileposts 35.25 and 35.35 on Interstate 80, the degradation of the interface signature occurred in several of the data passes simultaneously.

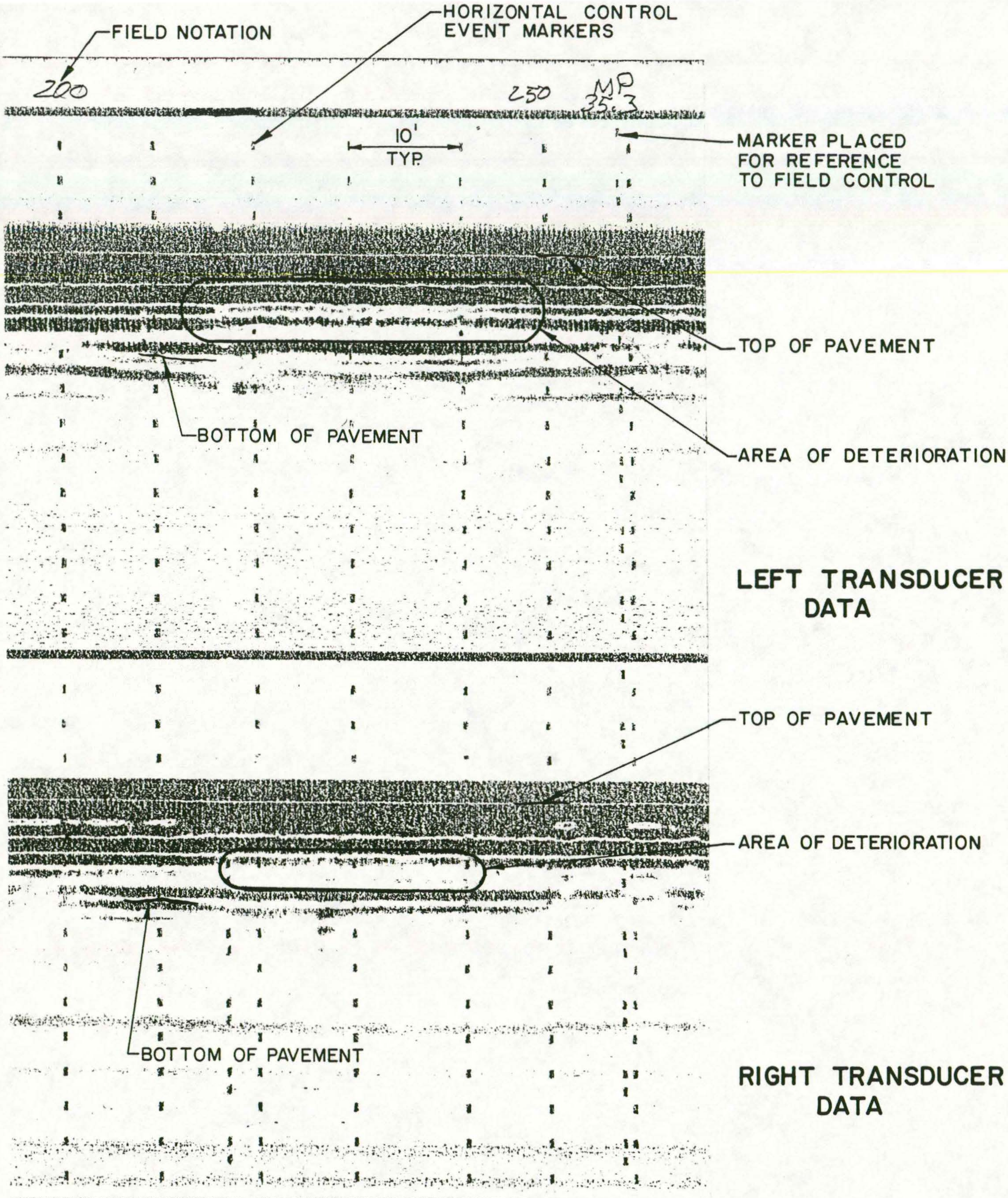

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FIGURE 5
SAMPLE OF GPR CHART SHOWING DETERIORATION SIGNATURE
IOWA DEPT. OF TRANSPORTATION

In both 1987 and 1988, 6,336 feet of GPR data was collected at each site and analyzed. The analysis of the 1987 data identified 258 lineal feet (4.1%) of scan that showed this deteriorated condition between mileposts 35.25 and 35.35. The analysis of the 1988 data identified an additional 46 lineal feet of this deteriorated condition, for a total of 304 lineal feet (4.8%). Also, the total square footage of patched area increased from 65 square feet to 468 square feet for this test section. For the test section between mileposts 36.00 and 36.10, the 116 lineal feet (1.8%) of this deteriorated condition which was identified in 1987, decreased slightly to 112 lineal feet (1.8%) in 1988. This decrease however, is directly related to an area of patching which did not exist at the time of the 1987 data collection. While no patching was observed in 1987, a total of 120 square feet was observed in 1988. Also, in the test section between mileposts 37.00 and 37.10, 96 lineal feet (1.5%) of this deteriorated condition was identified in 1988, while none was identified in 1987. A summary of these quantities can be found in Table 1, page 2-10. The location of this deterioration is shown in Appendix B. No GPR data representing any debonding that we can identify or deterioration was found at any of the other test sites.

Reference: T. Chung, C.R. Carter, D.G. Manning, F.B. Holt. "Signature Analysis of Radar Waveforms" Research and Development Branch, Ontario Ministry of Transportation and Communications, June 1984

TABLE 1

SUMMARY TABLE
EVALUATION OF BOND RETAINAGE
IN
PORTLAND CEMENT OVERLAYS

	1987	1988
Interstate 80	Station 35.25	Station 35.35
Total Area (sq. ft.)	12,672	12,672
Debond (IR) (sq. ft.)	None	None
Concrete Patch (sq. ft.)	65	468
Deterioration (GPR) (lin. ft.)	258	304
Interstate 80	Station 36.00	Station 36.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	None	120
Deterioration (GPR)	116	112
Interstate 80	Station 37.00	Station 37.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	None	None
Deterioration (GPR)	None	96
Interstate 80	Station 38.00	Station 38.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	None	None
Deterioration (GPR)	None	None
Interstate 80	Station 39.00	Station 39.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	None	None
Deterioration (GPR)	None	None

STH 141	Station 134.00 EB	Station 134.00 WB	Station 134.10 EB	Station 134.10 WB
Total Area	6,336	6,336	6,336	6,336
Debond (IR)	None	None	None	None
Concrete Patch	None	None	None	None
Deterioration (GPR)	None	None	None	None

STH 141	Station 134.90 EB	Station 134.90 WB	Station 135.00 EB	Station 135.00 WB
Total Area	6,336	6,336	6,336	6,336
Debond (IR)	None	None	None	None
Concrete Patch	None	None	None	None
Deterioration (GPR)	None	None	None	None

STH 141	Station 135.90 EB	Station 135.90 WB	Station 136.00 EB	Station 136.00 WB
Total Area	6,336	6,336	6,336	6,336
Debond (IR)	None	None	None	None
Concrete Patch	None	None	None	None
Deterioration (GPR)	None	None	None	None

STH 141	Station 137.00 EB	Station 137.00 WB	Station 137.10 EB	Station 137.10 WB
Total Area	6,336	6,336	6,336	6,336
Debond (IR)	None	None	None	None
Concrete Patch	None	72	None	72
Deterioration (GPR)	None	None	None	None

STH 141	Station 138.00 EB	Station 138.00 WB	Station 138.10 EB	Station 138.10 WB
Total Area	6,336	6,336	6,336	6,336
Debond (IR)	None	None	None	None
Concrete Patch	None	None	None	None
Deterioration (GPR)	None	None	Not Inspected (full depth repair)	

Interstate 80	Station 184.00	Station 184.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	13	13
Deterioration (GPR)	None	None

Interstate 80	Station 185.00	Station 185.10
Total Area	12,672	12,672
Debond (IR)	1	2
Concrete Patch	11	11
Deterioration (GPR)	None	None

Interstate 80	Station 186.00	Station 186.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	11	11
Deterioration (GPR)	None	None

Interstate 80	Station 187.00	Station 187.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	None	None
Deterioration (GPR)	None	None

Interstate 80	Station 188.00	Station 188.10
Total Area	12,672	12,672
Debond (IR)	None	None
Concrete Patch	None	None
Deterioration (GPR)	None	None

THERMAL INFRARED

CHAPTER 3

THERMAL INFRARED

INTRODUCTION

Infrared thermography was also used to identify debonding of the concrete overlay in this project. An infrared scanner was used to locate these areas by observing the temperature difference between debonded areas and sound concrete which exists when the pavement is warmed by the sun's energy. Cracks beneath a debonded area act as an insulator, permitting the debond to become warmer than the surrounding, more massive pavement. Temperature differences can reach 5° C on bright, sunny days. The technique has the principle advantages of faster data collection, less operator judgement and more accurate results than traditional sounding procedures.

EQUIPMENT

The infrared scanner used for this work is a small, light-weight field instrument capable of detecting emitted thermal radiation. It produces a standard video signal that allows thermal imagery to be recorded on videotape. This scanner is capable of measuring temperature differences of 0.2° C. The scanner uses a mercury cadmium telluride (HgCdTe) detector which is cooled by liquid nitrogen. A 45° expander lens was used, which allowed the operator to view a pavement width of one and one-quarter lanes. This permitted some overlap from lane to lane for analysis purposes and allowed minor vehicle movement during data collection.

A color video camera and recorder were also used to obtain control images of the pavement. This camera was equipped with a zoom lens which allowed the field of view for the control image and the infrared image to be matched.

A digital distance measuring device was used to reference the imagery to a known starting point. Distance measurements were superimposed on both the infrared video image and the control image. A digital contact thermometer was used to measure the temperature difference between sound and deteriorated pavement for calibration purposes. An anemometer was used to measure wind speed, and a sling psychrometer was used to measure the relative humidity.

PROCEDURES

The infrared scanner and video camera were mounted on a hydraulic mast attached to the front of the inspection van and raised to approximately 14 feet above the bridge deck, as shown in Figure 6. Black and white video produced by the infrared scanner and color video produced by the control camera were displayed on monitors in the van, shown in Figure 7. The operator controlled the quality of the thermographic data being produced. The speed of the scanning van was held to approximately two miles per hour along the center of each traffic lane. A single pass was made for each selected lane of pavement.

Once the van was in position at a reference point, the distance measuring device was zeroed. During the scanning operation the van was stopped periodically at an area of suspect debonding for the purpose of confirming the infrared data. This consisted of sounding the pavement to confirm the presence of a debonded area.

Figure 6 Infrared data collection van

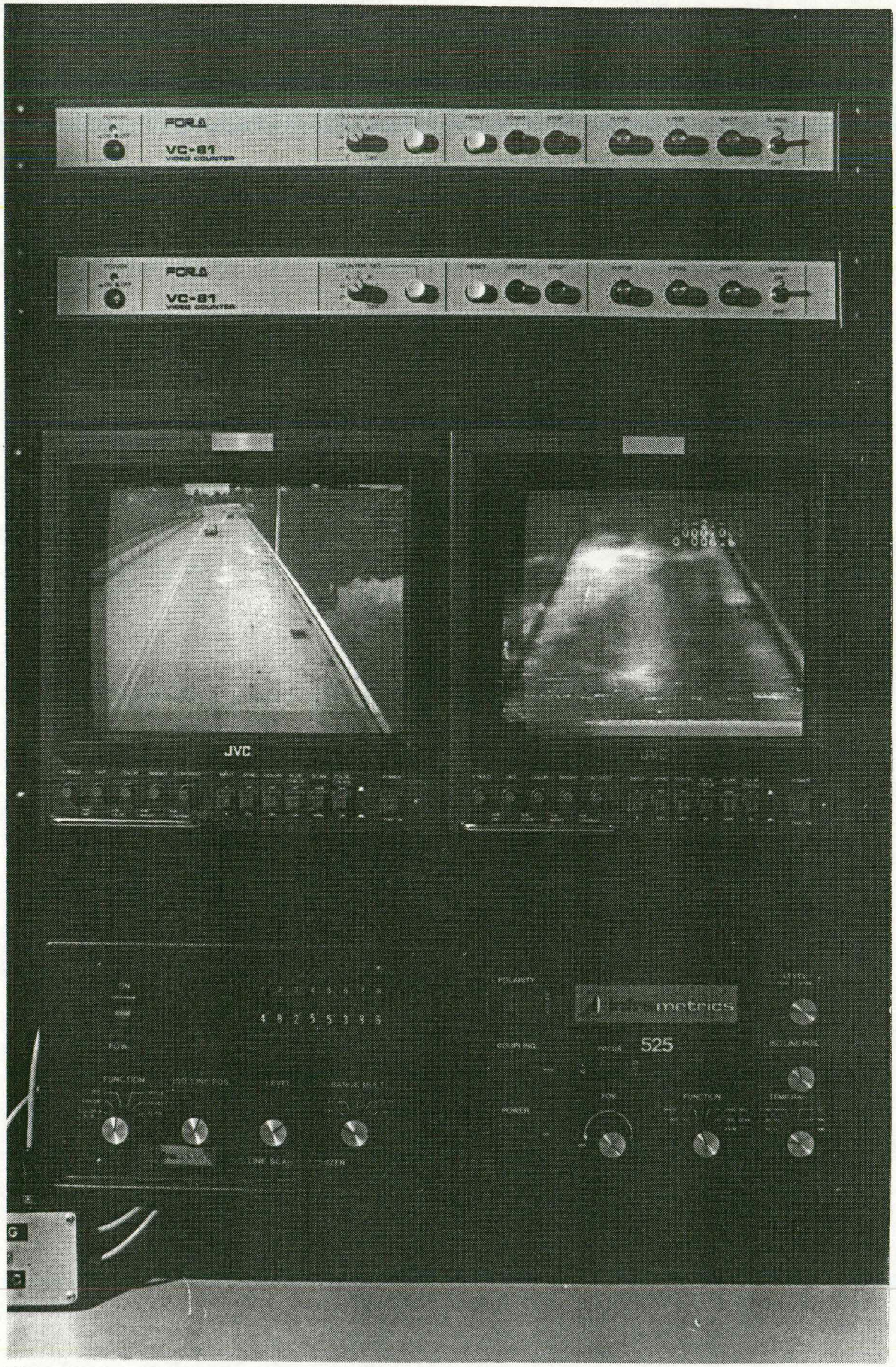


Figure 7 Interior of remote sensing van

Surface temperature measurements were also taken at both the debonded area and adjacent sound area. A total of five confirmation cores, three in 1987 and two in 1988, were marked on the pavement for coring at a later date.

Certain environmental conditions are required for thermography to be effective. Generally clear skies, winds less than 15 miles per hour, and dry pavement produce suitable temperature differentials between sound and debonded areas. If these conditions do not occur, a detectable temperature differential is not established. The infrared thermographic survey was conducted on August 18 through 20, 1987 and August 9 through 11, 1988.

The conditions experienced on the inspection days are summarized below:

Date	Ambient Temperature (°F)	Weather Conditions	Wind Speed (mph)	Humidity (%)	Pavement Temperature Difference (°F)
8-18-87	78	Clear	3	46	--
8-19-87	81	P. Cloudy	5	58	--
8-20-87	78	P. Cloudy	8	67	1.5
8-09-88	90	Clear	2	42	--
8-10-88	95	P. Cloudy	7	50	--
8-11-88	91	Clear	5	47	--

Traffic control was provided by the Iowa Department of Transportation. This consisted of two arrow boards which were used to alert drivers to move to adjacent lanes.

The survey vehicle was equipped with amber beacons and a directional arrow for additional traffic control.

ANALYSIS

The analysis procedure consisted of a computer-aided interpretation of the video tape produced during the field operation. The location of each thermal anomaly shown on the infrared video was plotted by the computer on a 1" : 20' scale plan view. Anomalies show up as white or hot areas compared to sound areas which are dark or cooler on the video tape. The control video tape was simultaneously examined to make sure that an anomaly was not caused by discoloration, patching or debris.

Based on correlations between the thermal signatures and the coring results, the thermal anomalies identified were debonds.

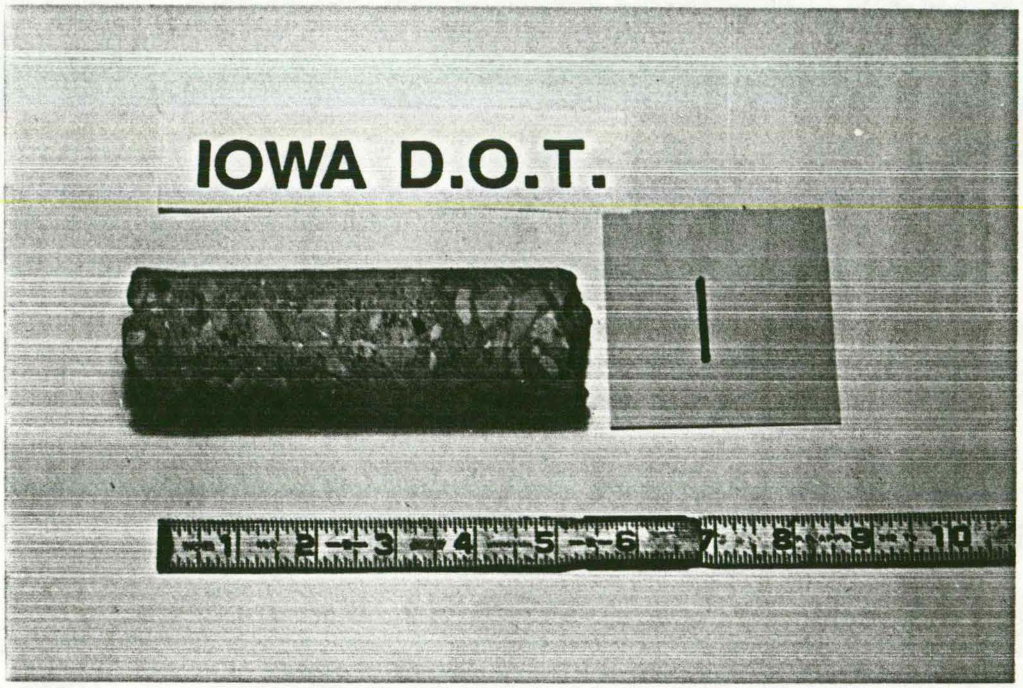
RESULTS

The results of the infrared scanning showed that no debonding of the overlay is present in the five test sections of pavement on Interstate 80 eastbound between mileposts 35.25 and 39.10. This is confirmed by the eleven cores (Nos. 1-5 in 1987 and Nos. 1-6 in 1988) which were taken in these sections. Also, no debonding was identified in the five test sections on S.H. 141 between mileposts 134.00 and 138.10. This is confirmed by the four cores (nos. 6, 7, 8 and 9) taken in 1987 and the three cores (Nos. 7, 8, and 9) taken in 1988. An area of patching was observed in both 1987 and 1988 between mileposts 137.00 and 137.10 with a total area of approximately 72 square feet. In the five test sections of pavement on Interstate 80 westbound between milepost 184.00 and 188.10, one square foot of debonding was located adjacent to an existing patch (11 square feet) between milepost 185.00 and 185.10 in 1987. The location of the debond was 247 feet west of milepost 185.10 and three and one-half feet south of the north edge of the pavement. Core 10 was taken at this location and showed a debond to be present. In 1988, an additional one square foot of debonding was identified at the same location, within the existing patch. This debond was confirmed by Core #12. In addition, eleven square feet of patching was observed in both 1987 and 1988 in the section of pavement between mileposts 186.00 and 186.10. No other defects were observed in these test sections. This is confirmed by the five other cores (Nos. 11-13 in 1987 and 10-11 in 1988) taken in these areas. Detailed descriptions of the cores can be found in Appendix A. Also, a summary of the IR and GPR results can be found in Table 1 on page 2-10, as well as the planviews in Appendix B.

The results of the infrared scanning correlated very well with those of the ground penetrating radar survey. Both techniques indicate that very little, if any, debonding of the overlay is present. Any deterioration of the pavement is a result of the original pavement failing, not the bond between the overlay and the original pavement. This was verified by the cores in the section of pavement on Interstate 80 between milepost 35.25 and 39.10. Both systems utilized rely on the presence of an air gap at the PCC overlay/original pavement interface for the detection of a debond. For the infrared this air gap creates a thermal discontinuity in the pavement which is detectable under certain weather conditions. In the ground penetrating radar, this air gap changes the dielectric properties of the interface between the original pavement and the PCC overlay which is then recorded in the return wave form. The only location where this air gap was located was on Interstate 80 between mileposts 185.00 and 185.10. The ground penetrating radar did detect areas where weak concrete below the bond was present. This condition is a very early stage of deterioration where numerous small fractures occur. This condition will continue to deteriorate and will ultimately fail and debond.

APPENDIX A

CORE LOG



DEPTH

1"	PCC
2"	
3"	
4"	
5"	
6"	
7"	
8"	
9"	
10"	
11"	
12"	
13"	
14"	
15"	

DATE: August 9, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (EB Passing) - Milepost 35.25

CORE: # 1

DIAMETER: 2 inch

OVERLAY THICKNESS: 3.75 inches

CONCRETE THICKNESS: 5.5 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: Poor original pavement

QUALITY OF CONCRETE: Poor

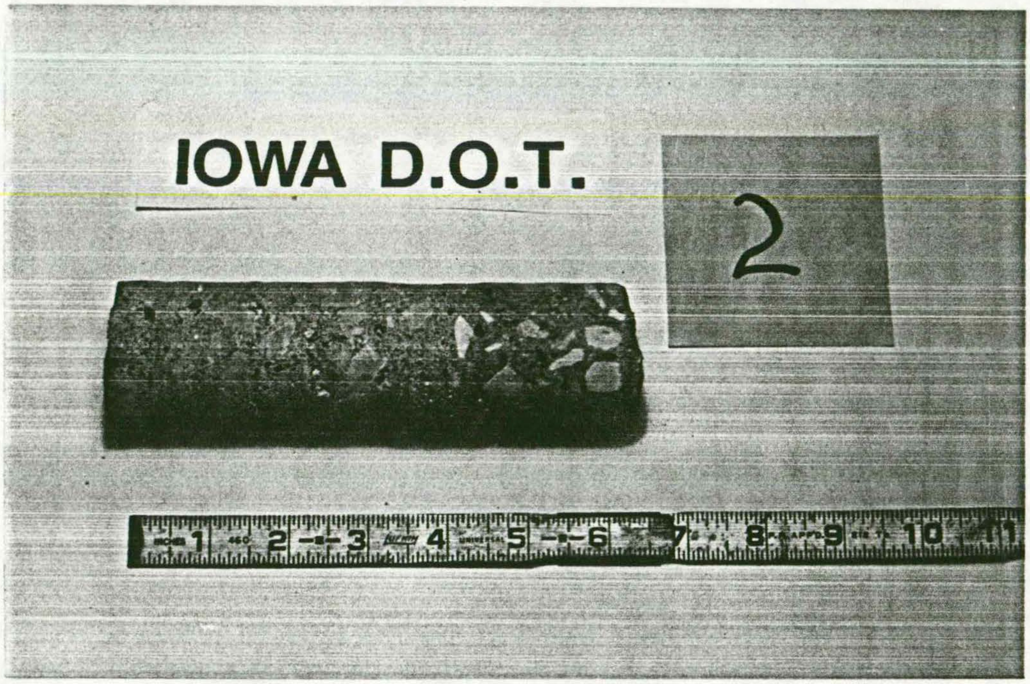
REMARKS: Original pavement broke easily

JOINT

CURB

PLANVIEW

CORE LOG



DEPTH

Depth	
1"	
2"	PCC
3"	
4"	
5"	
6"	
7"	
8"	
9"	
10"	
11"	
12"	
13"	
14"	
15"	

DATE: August 9, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (EBPassing) - Milepost 35.25

CORE: # 2

DIAMETER: 2 inch

OVERLAY THICKNESS: 4.25 inches

CONCRETE THICKNESS: 6.0 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: Poor original pavement

QUALITY OF CONCRETE: Poor

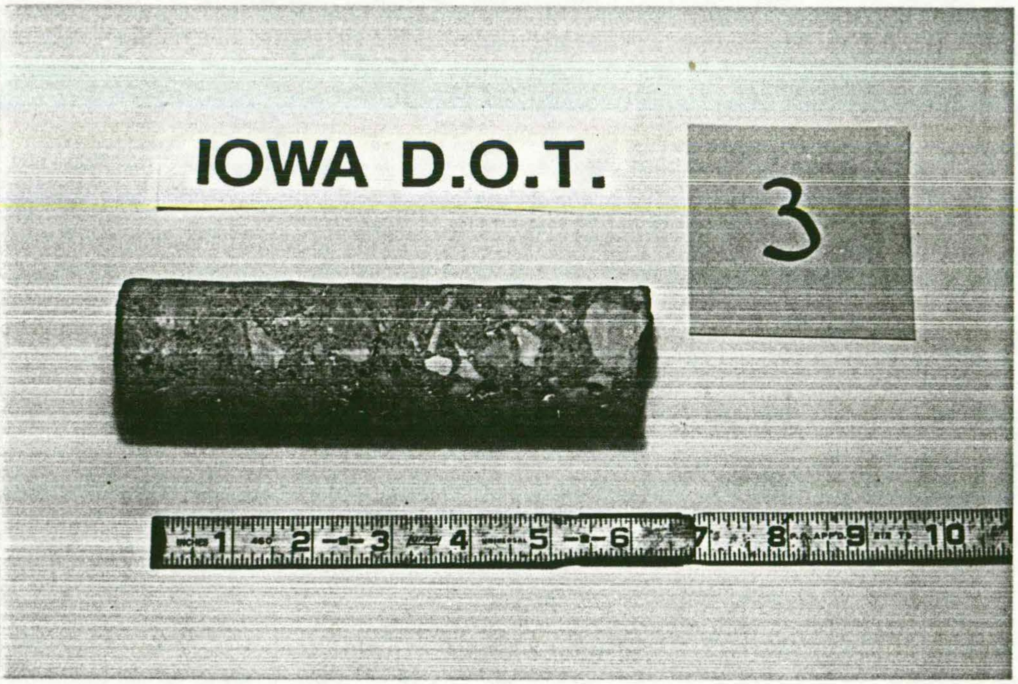
REMARKS: Original pavement broke easily

JOINT

CURB

PLANVIEW

CORE LOG



DEPTH

Depth	
1"	
2"	PCC
3"	
4"	
5"	
6"	
7"	
8"	
9"	
10"	
11"	
12"	
13"	
14"	
15"	

DATE: August 9, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (EB Passing) - Milepost 36.00

CORE: # 3

DIAMETER: 2 inch

OVERLAY THICKNESS: 3.5 inches

CONCRETE THICKNESS: 6.25 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: Fair original pavement

QUALITY OF CONCRETE: Fair

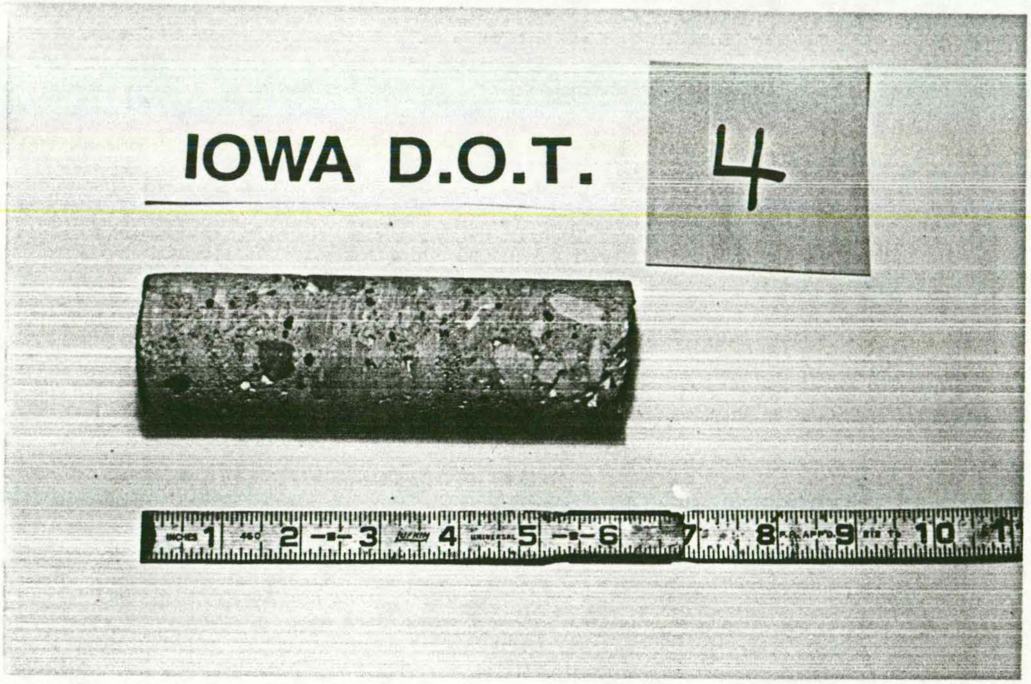
REMARKS: Original pavement broke with slight pressure

JOINT

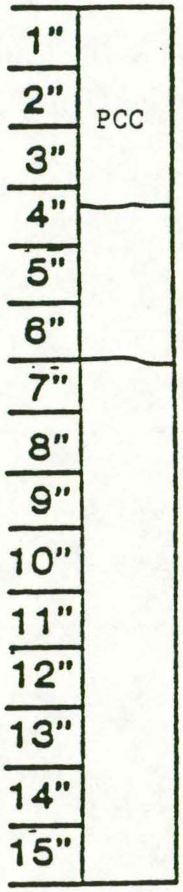
CURB

PLANVIEW

CORE LOG



DEPTH



DATE: August 9, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (EB Passing) - Milepost 37.00

CORE: # 4

DIAMETER: 2 inch

OVERLAY THICKNESS: 3.25 inches

CONCRETE THICKNESS: 6.0 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: Fair original pavement

QUALITY OF CONCRETE: Fair

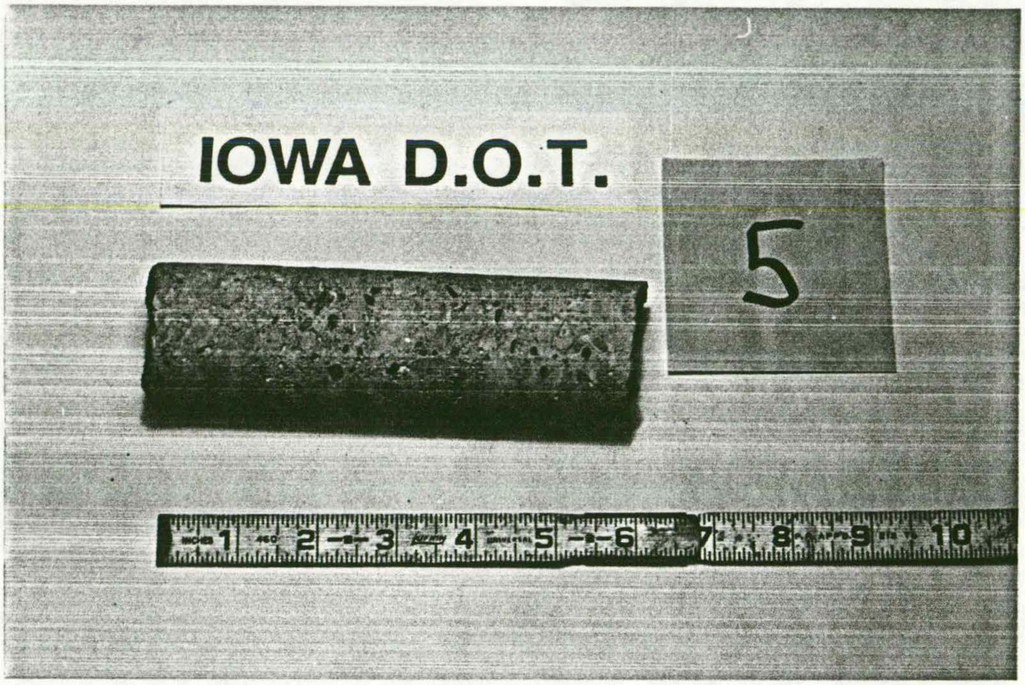
REMARKS: Original pavement broke with slight pressure

JOINT

CURB

PLANVIEW

CORE LOG



DEPTH

1"
2" PCC
3"
4"
5"
6"
7"
8"
9"
10"
11"
12"
13"
14"
15"

DATE: August 9, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (EB Passing) - Milepost 39.00

CORE: # 5

DIAMETER: 2 inch

OVERLAY THICKNESS: 4.5 inches

CONCRETE THICKNESS: 6.0 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: Fair original pavement

QUALITY OF CONCRETE: Fair

REMARKS: Original pavement broke with slight pressure

JOINT

CURB

PLANVIEW

CORE LOG

DEPTH

1"	
2"	PCC
3"	
4"	
5"	
6"	
7"	
8"	
9"	
10"	
11"	
12"	
13"	
14"	
15"	

DATE: August 9, 1988

PROJECT: Iowa DOT

CORE LOCATION: I-80 (EB Passing) - Milepost 39.00

CORE: # 6

DIAMETER: 2 inch

OVERLAY THICKNESS: 4.25 inches

CONCRETE THICKNESS: 6.5 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: Poor original pavement

QUALITY OF CONCRETE: Poor

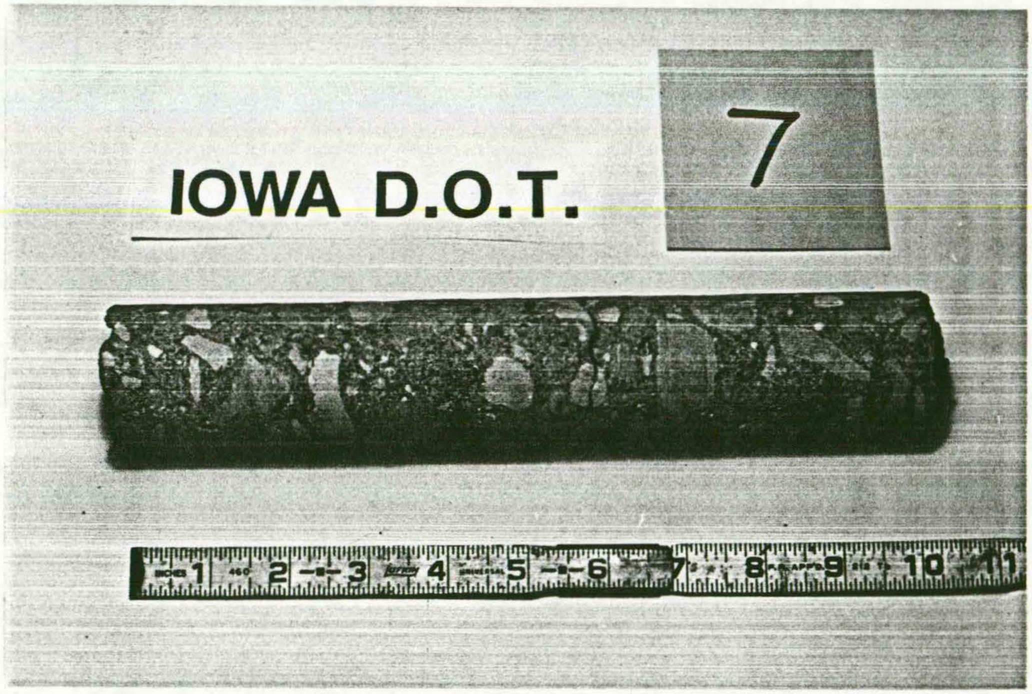
REMARKS: Original pavement broke easily

JOINT

CURB

PLANVIEW

CORE LOG



DEPTH

1"
2"
3"
4"
5"
6"
7"
8"
9"
10"
11"
12"
13"
14"
15"

DATE: August 10, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: SH 141 (EB) - Milepost 138.00

CORE: # 7

DIAMETER: 2 inch

OVERLAY THICKNESS: N/A

CONCRETE THICKNESS: 10.25 inches

FULL DEPTH Y/N: Yes

CONDITION OF OVERLAY: N/A

DEFECTS IN CORE: None

QUALITY OF CONCRETE: Good

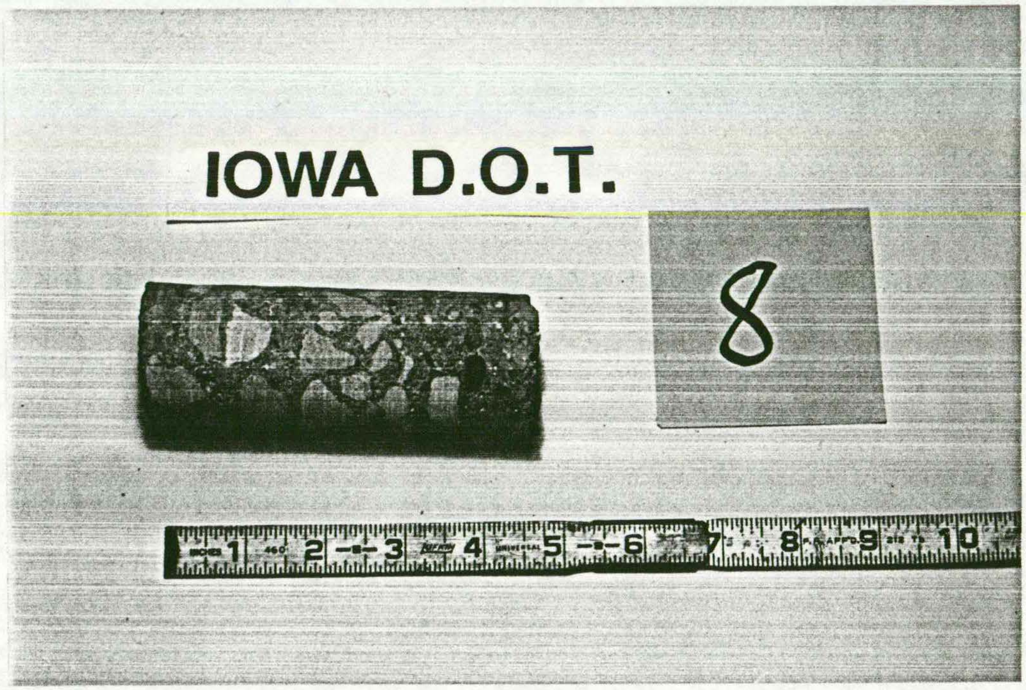
REMARKS: Core broke as a result of the coring procedure

JOINT

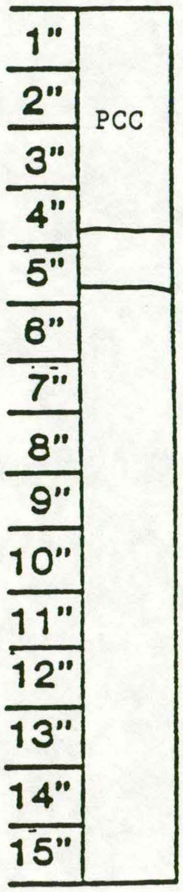
CURB

PLANVIEW

CORE LOG



DEPTH



DATE: August 10, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: SH 141 (WB) - Milepost 135.90

CORE: # 8

DIAMETER: 2 inch

OVERLAY THICKNESS: 3.75 inches

CONCRETE THICKNESS: 4.75 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: None

QUALITY OF CONCRETE: Fair

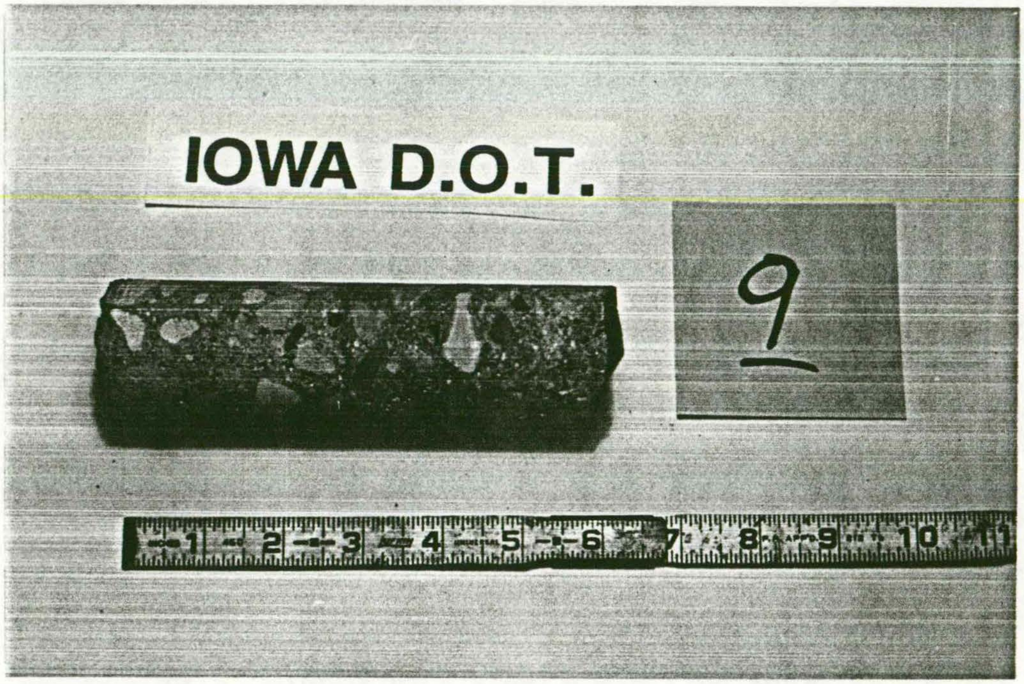
REMARKS:

JOINT

CURB

PLANVIEW

CORE LOG



DEPTH

1"	
2"	PCC
3"	
4"	
5"	
6"	
7"	
8"	
9"	
10"	
11"	
12"	
13"	
14"	
15"	

DATE: August 10, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: SH 141 (WB) - Milepost 134.00

CORE: # 9

DIAMETER: 2 inch

OVERLAY THICKNESS: 3.0 inches

CONCRETE THICKNESS: 6.25 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: None

QUALITY OF CONCRETE: Fair

REMARKS:

JOINT

CURB

PLANVIEW

CORE LOG

DEPTH

Depth	
1"	
2"	PCC
3"	
4"	
5"	
6"	
7"	
8"	
9"	
10"	
11"	
12"	
13"	
14"	
15"	

DATE: August 11, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (WB Driving) - Milepost 188.00

CORE: # 10

DIAMETER: 2 inch

OVERLAY THICKNESS: 4.75 inches

CONCRETE THICKNESS: 8.0 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: None

QUALITY OF CONCRETE: Fair

REMARKS:

JOINT

CURB

PLANVIEW

CORE LOG

DEPTH

Depth	
1"	
2"	PCC
3"	
4"	
5"	
6"	
7"	
8"	
9"	
10"	
11"	
12"	
13"	
14"	
15"	

DATE: August 11, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (WB Driving) - Milepost 186.00

CORE: # 11

DIAMETER: 2 inch

OVERLAY THICKNESS: 6.5 inches

CONCRETE THICKNESS: 8.25 inches

FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: None

QUALITY OF CONCRETE: Good

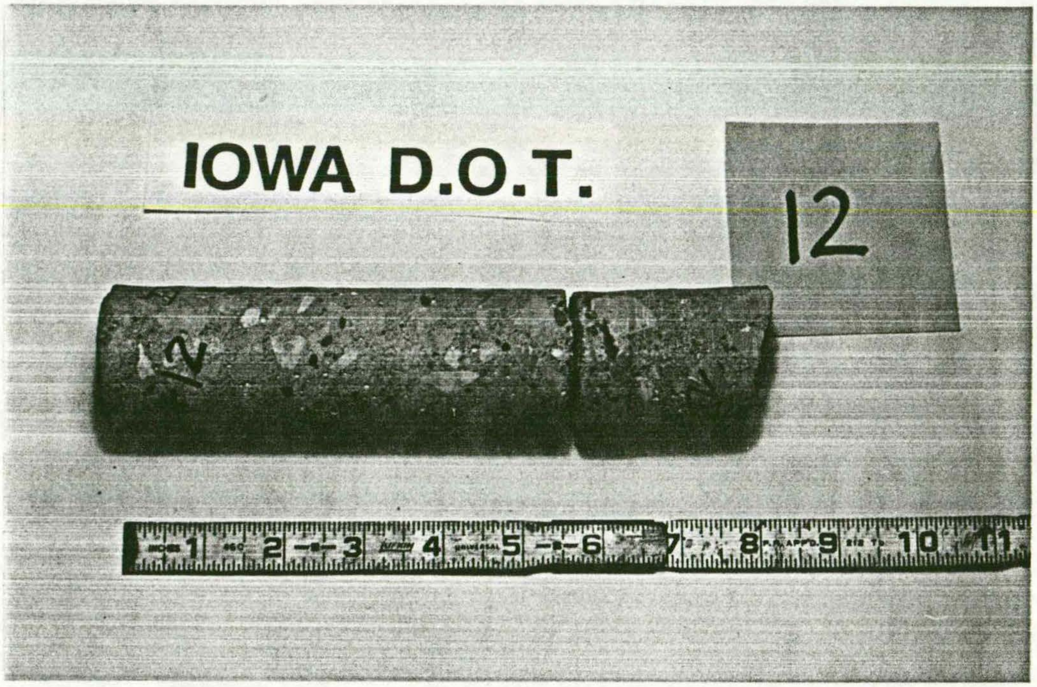
REMARKS: Core broke at bond when extracted from core hole

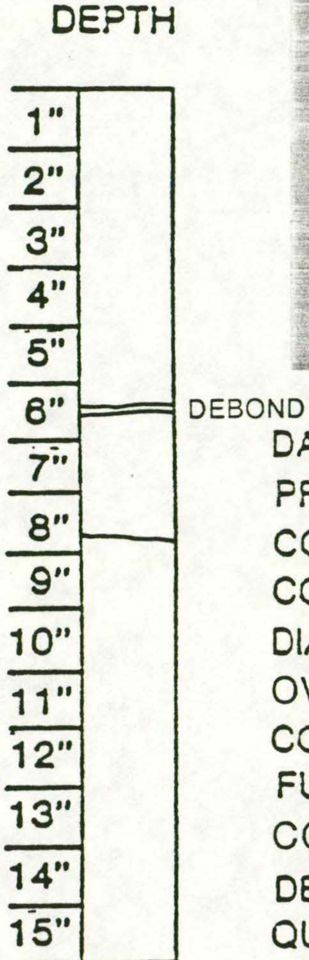
JOINT

CURB

PLANVIEW

CORE LOG





DATE: August 11, 1988

PROJECT: Iowa DOT - PCC Bond Evaluation

CORE LOCATION: I-80 (WB Driving) - Milepost 185.00

CORE: # 12

DIAMETER: 2 inch

OVERLAY THICKNESS: N/A

CONCRETE THICKNESS: 7.75 inches

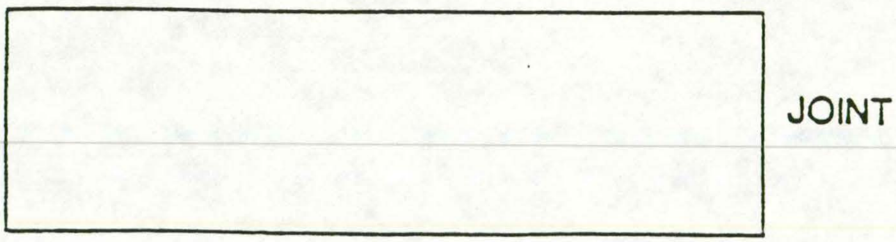
FULL DEPTH Y/N: No

CONDITION OF OVERLAY: Good

DEFECTS IN CORE: Debond at 5.5 inches

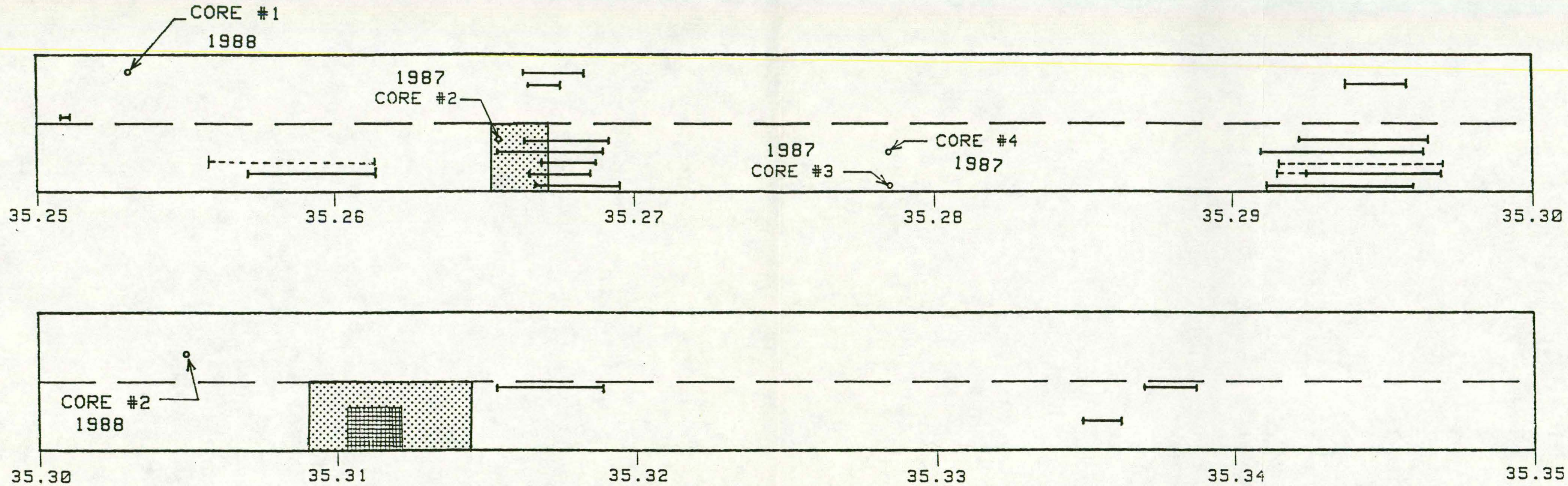
QUALITY OF CONCRETE: Good

REMARKS: Core was taken in a patched area



PLANVIEW

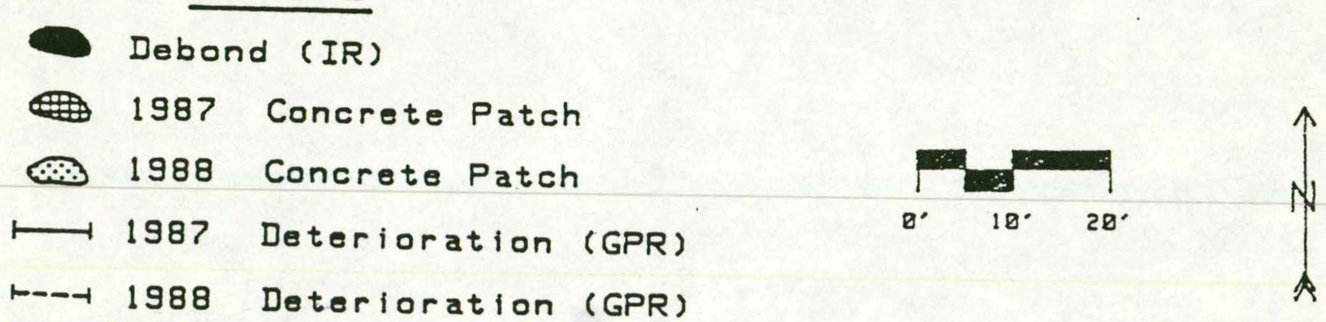
APPENDIX B



AREAS	EASTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	468 (sq.ft.)
Deterioration (GPR)	304 (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND



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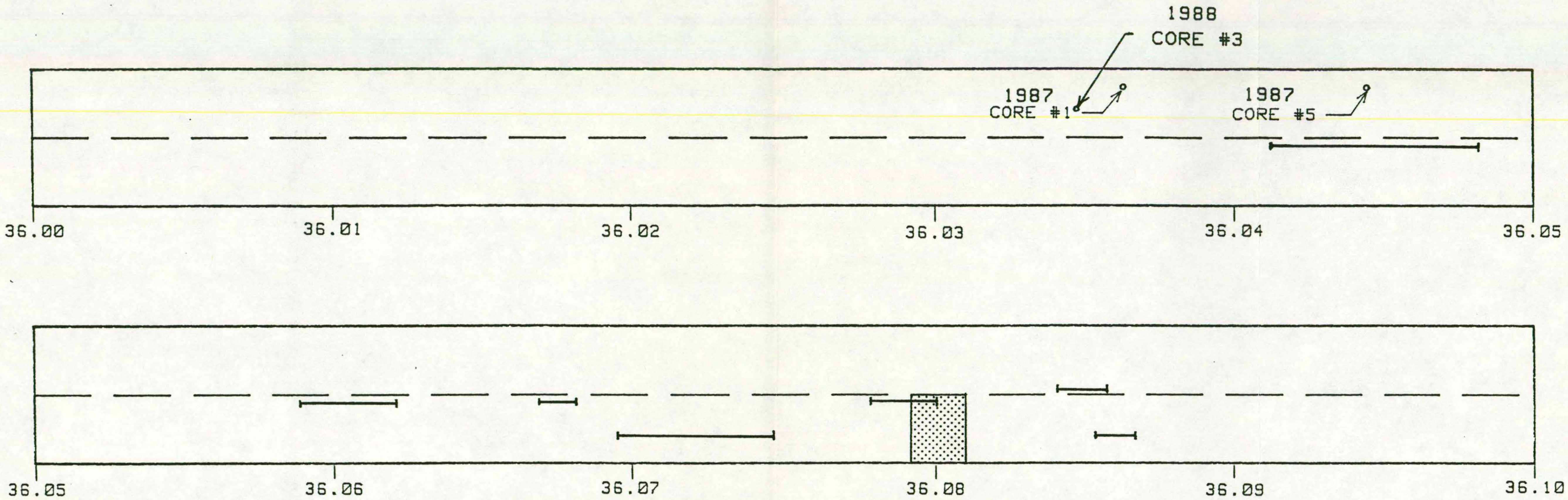
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (EASTBOUND) STA 35.25 TO STA 35.35
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	EASTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	120 (sq.ft.)
Deterioration (GPR)	112 (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

Debond (IR)
1987 Concrete Patch
1988 Concrete Patch
1987 Deterioration (GPR)
1988 Deterioration (GPR)

0′ 10′ 20′

N

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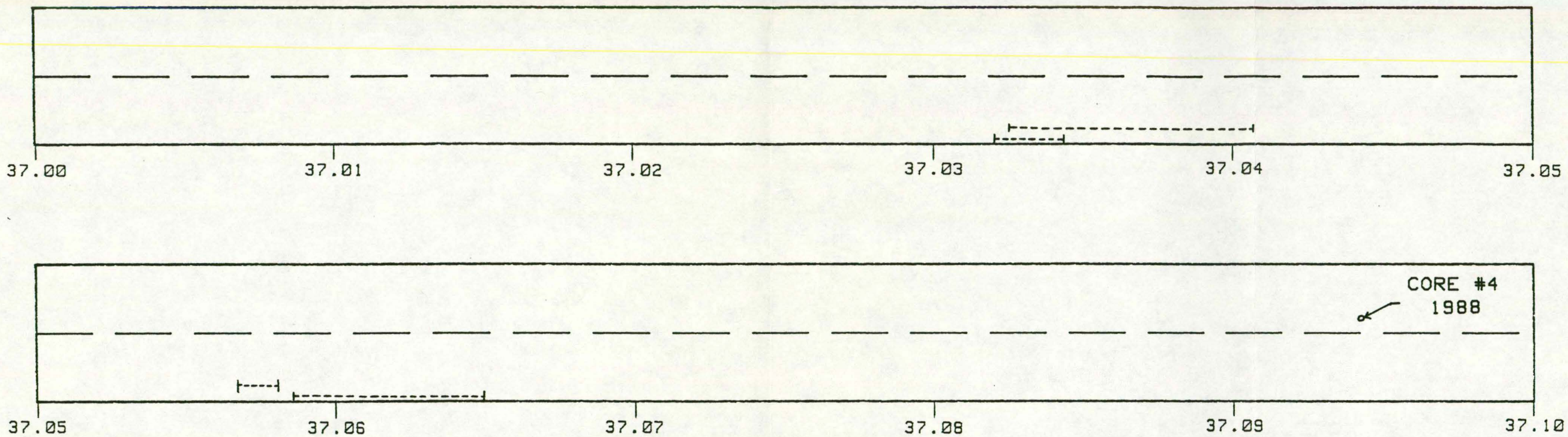
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (EASTBOUND) STA 36.00 TO STA 36.10
IOWA DEPARTMENT OF TRANSPORTATION

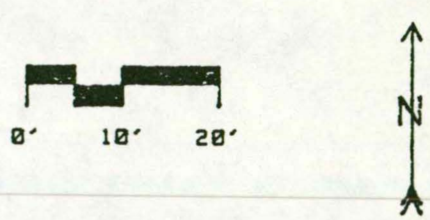


AREAS	EASTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	None (sq.ft.)
Deterioration (GPR)	96 (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

- Debond (IR)
- 1987 Concrete Patch
- 1988 Concrete Patch
- 1987 Deterioration (GPR)
- 1988 Deterioration (GPR)



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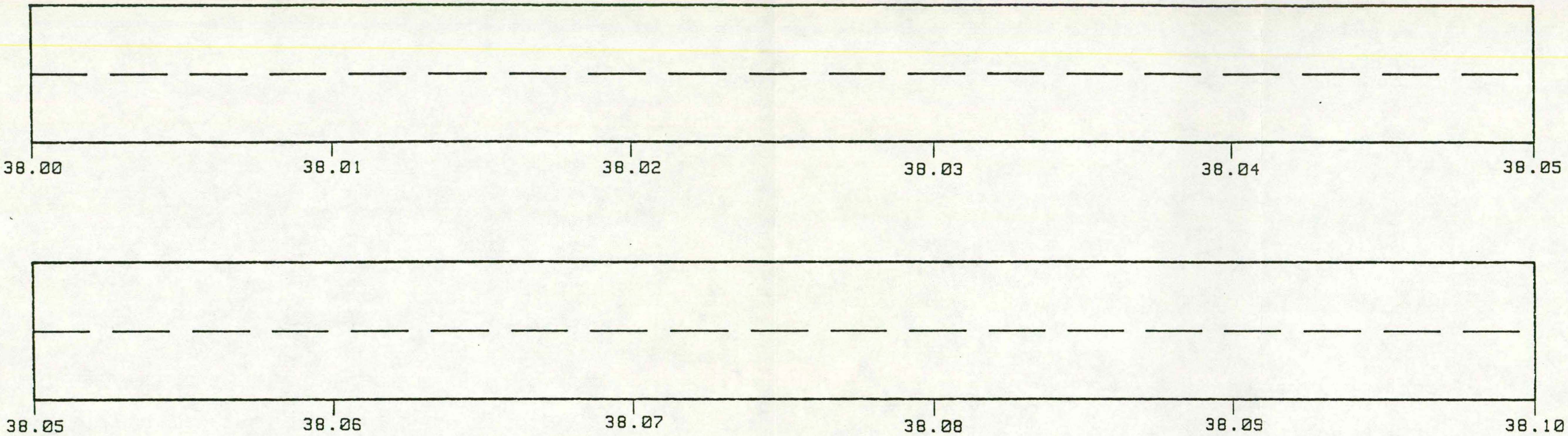
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (EASTBOUND) STA 37.00 TO STA 37.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	EASTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	None (sq.ft.)
Deterioration (GPR)	None (lin.ft.)

Inspection Date: August, 1987

August, 1988

LEGEND

- Debond (IR)
- 1987 Concrete Patch
- 1988 Concrete Patch
- 1987 Deterioration (GPR)
- 1988 Deterioration (GPR)

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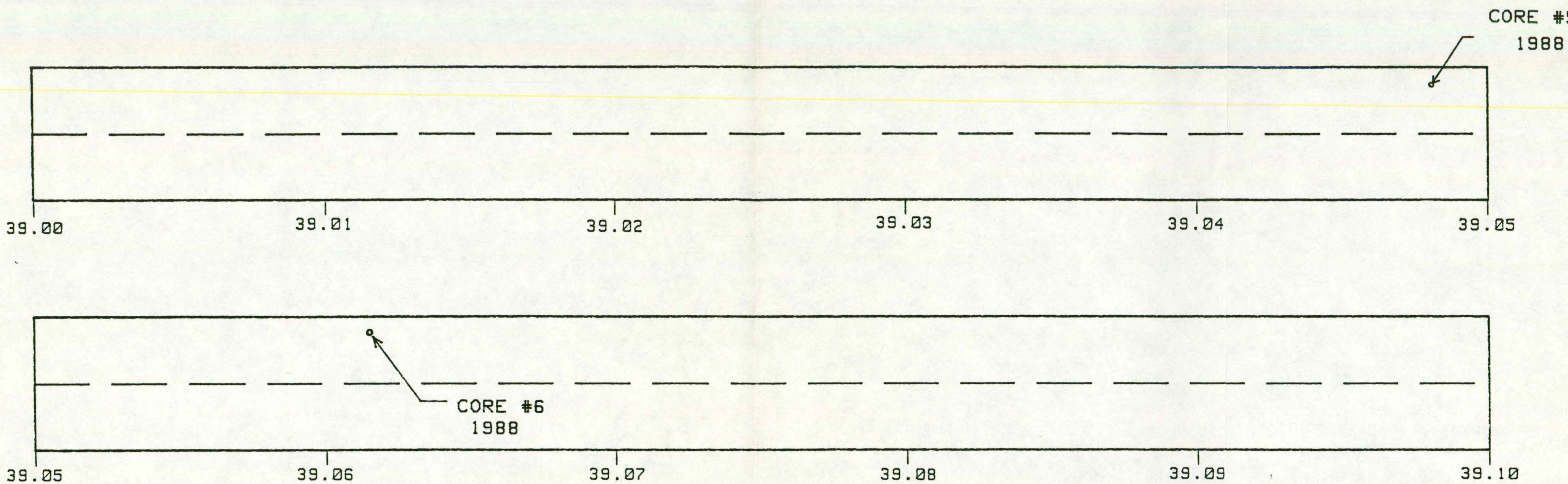
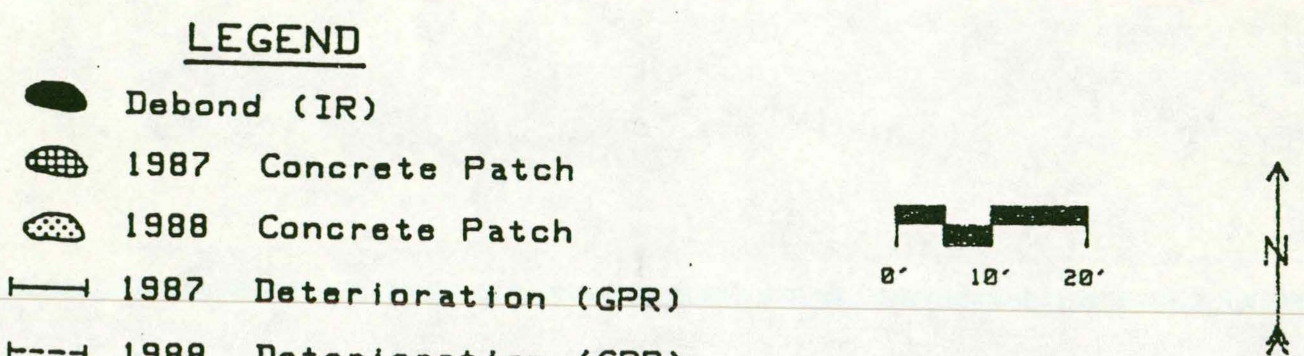
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (EASTBOUND) STA 38.00 TO STA 38.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	EASTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	None (sq.ft.)
Deterioration (GPR)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988



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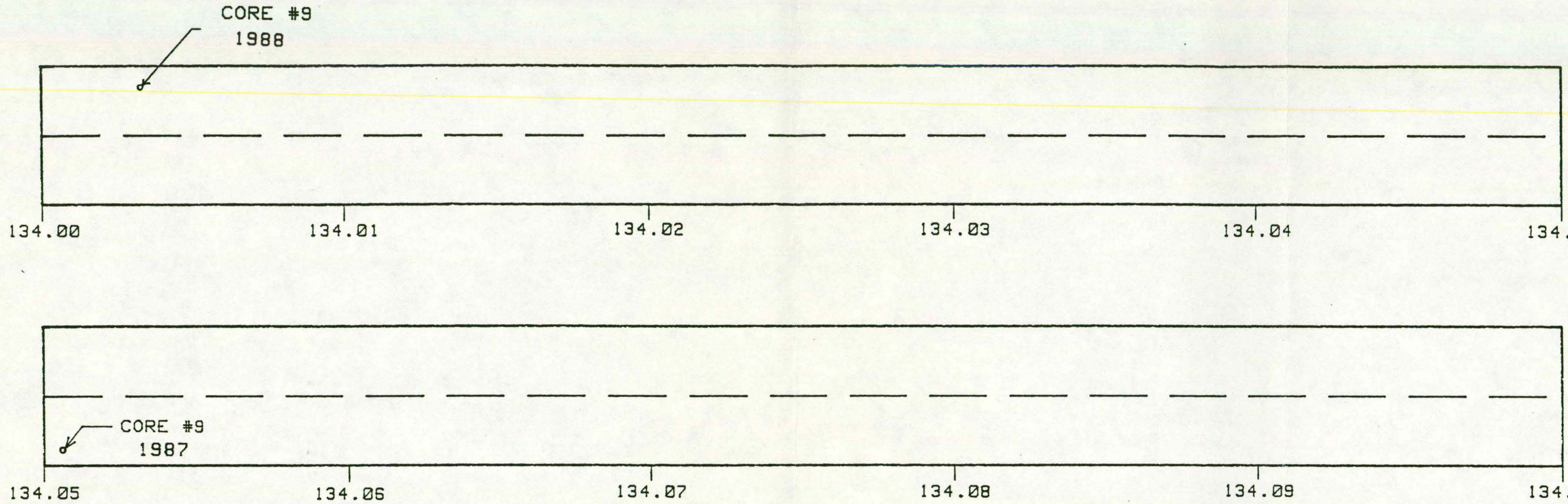
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (EASTBOUND) STA 39.00 TO STA 39.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	EASTBOUND LANES	WESTBOUND LANES
Total Area	6,336 (sq.ft)	6,336 (sq.ft.)
Debond (IR)	None (sq.ft.)	None (sq.ft.)
Concrete Patch	None (sq.ft.)	None (sq.ft.)
Deterioration (GPR)	None (lin.ft.)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

- Debond (IR)
- 1987 Concrete Patch
- 1988 Concrete Patch
- 1987 Deterioration (GPR)
- 1988 Deterioration (GPR)

0' 10' 20'

N

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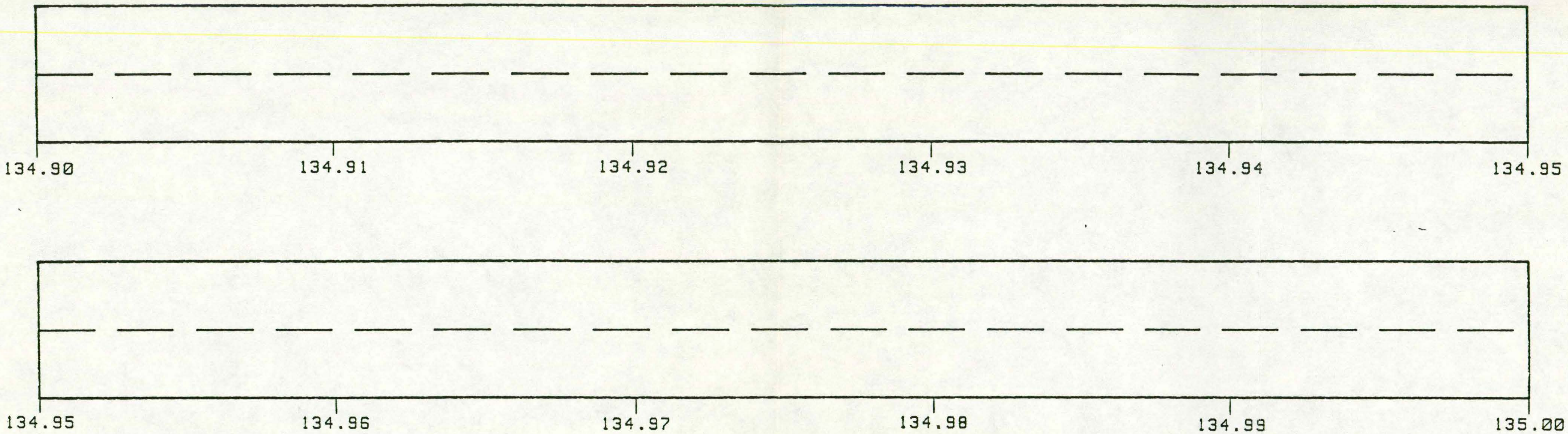
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
SH141 (EB & WB) STA 134.00 TO STA 134.10
IOWA DEPARTMENT OF TRANSPORTATION

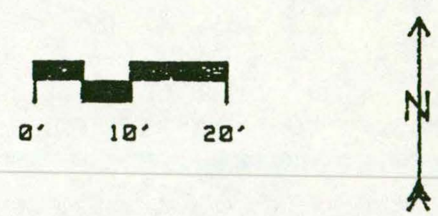


AREAS	EASTBOUND LANES	WESTBOUND LANES
Total Area	6,336 (sq.ft)	6,336 (sq.ft.)
Debond (IR)	None (sq.ft.)	None (sq.ft.)
Concrete Patch	None (sq.ft.)	None (sq.ft.)
Deterioration (GPR)	None (lin.ft.)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

Debond (IR)
1987 Concrete Patch
1988 Concrete Patch
1987 Deterioration (GPR)
1988 Deterioration (GPR)



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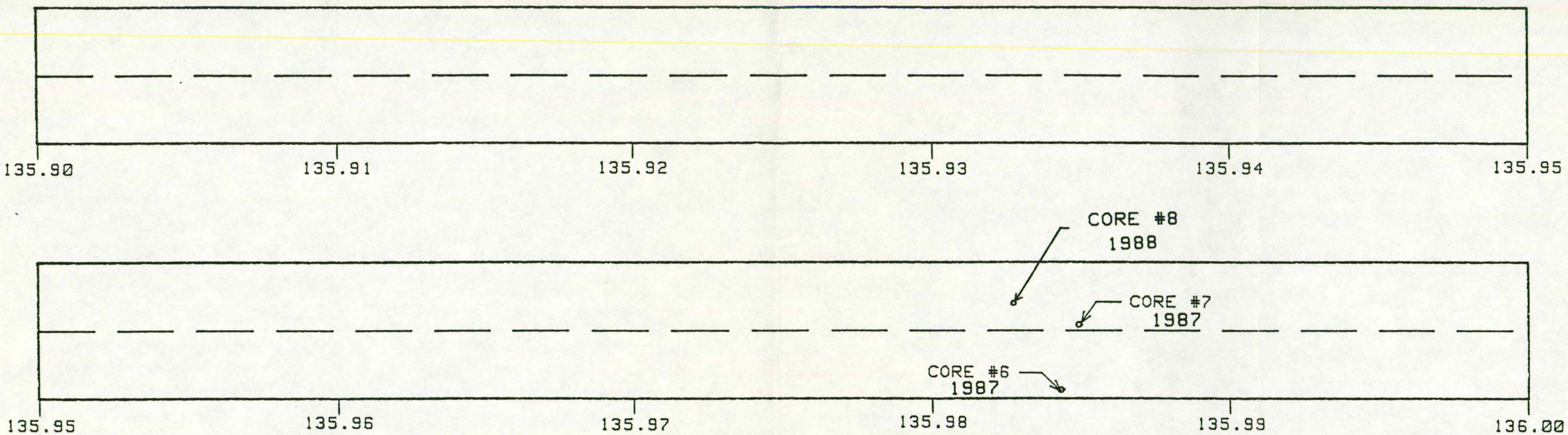
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
SH141 (EB & WB) STA 134.90 TO STA 135.00
IOWA DEPARTMENT OF TRANSPORTATION

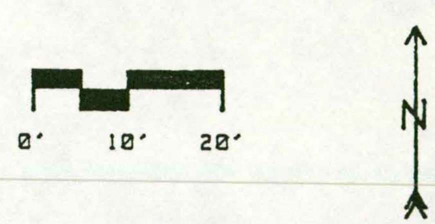


AREAS	EASTBOUND LANES	WESTBOUND LANES
Total Area	6,336 (sq.ft)	6,336 (sq.ft.)
Debond (IR)	None (sq.ft.)	None (sq.ft.)
Concrete Patch	None (sq.ft.)	None (sq.ft.)
Deterioration (GPR)	None (lin.ft.)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

Debond (IR)
1987 Concrete Patch
1988 Concrete Patch
1987 Deterioration (GPR)
1988 Deterioration (GPR)



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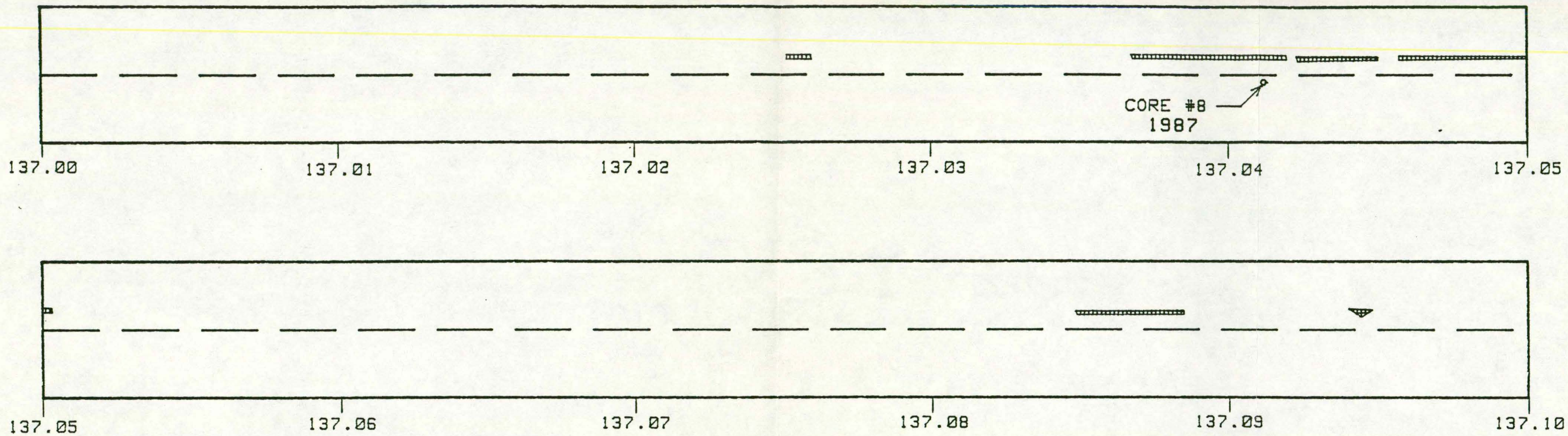
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
SH141 (EB & WB) STA 135.90 TO STA 136.00
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	EASTBOUND LANES	WESTBOUND LANES
Total Area	6,336 (sq.ft)	6,336 (sq.ft.)
Debond (IR)	None (sq.ft.)	None (sq.ft.)
Concrete Patch	None (sq.ft.)	72 (sq.ft.)
Deterioration (GPR)	None (lin.ft.)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

- Debond (IR)
- 1987 Concrete Patch
- 1988 Concrete Patch
- 1987 Deterioration (GPR)
- 1988 Deterioration (GPR)

0′ 10′ 20′

N

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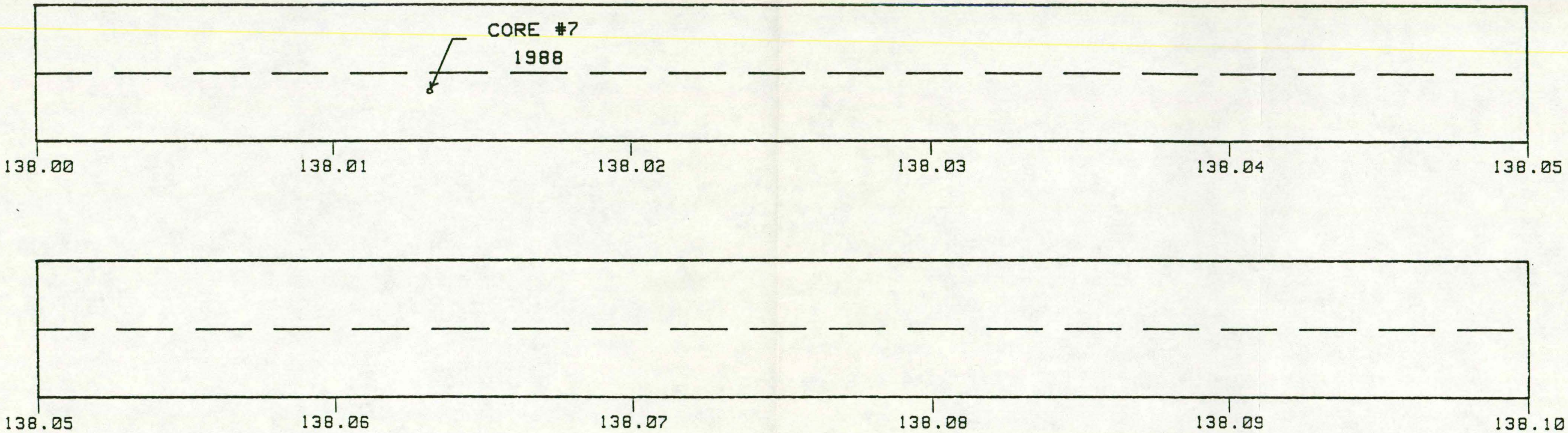
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
SH141 (EB & WB) STA 137.00 TO STA 137.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	EASTBOUND LANES	WESTBOUND LANES
Total Area	6,336 (sq.ft)	6,336 (sq.ft.)
Debond (IR)	None (sq.ft.)	None (sq.ft.)
Concrete Patch	None (sq.ft.)	None (sq.ft.)
Deterioration (GPR)	Not Inspected 1988	Full Depth Replacement

Inspection Date: August, 1987
August, 1988

LEGEND

Debond (IR)
1987 Concrete Patch
1988 Concrete Patch
1987 Deterioration (GPR)
1988 Deterioration (GPR)

0' 10' 20'

N

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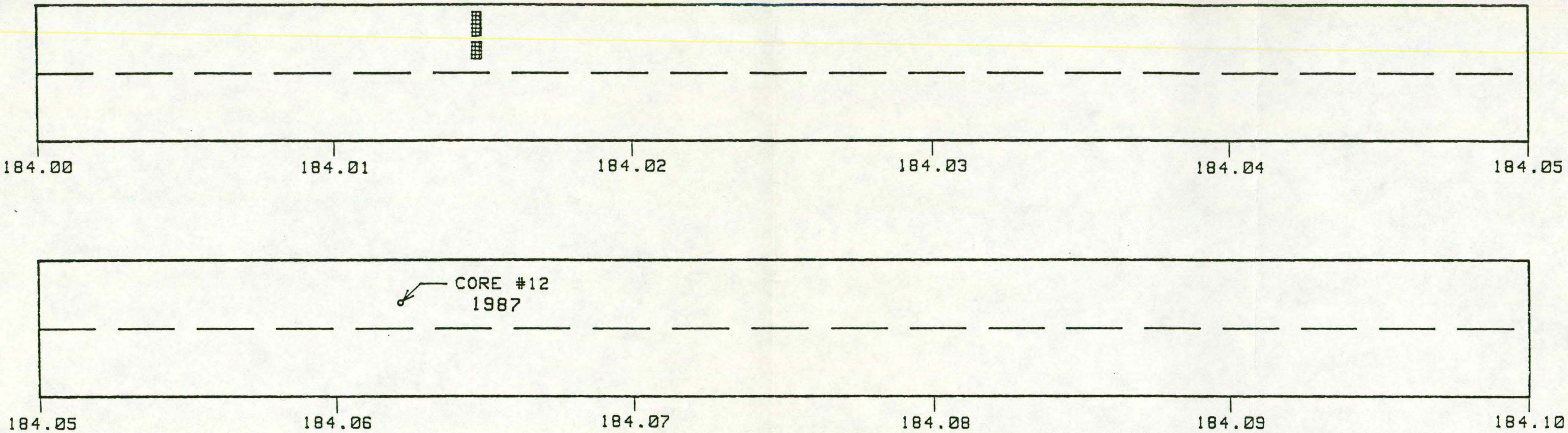
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
SH141 (EB & WB) STA 138.00 TO STA 138.10
IOWA DEPARTMENT OF TRANSPORTATION

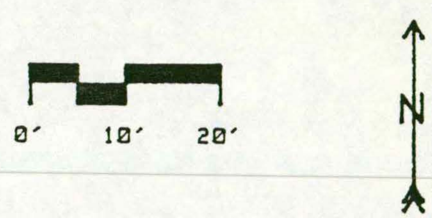


AREAS	WESTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	13 (sq.ft.)
Deterioration (GPR)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

- Debond (IR)
- 1987 Concrete Patch
- 1988 Concrete Patch
- 1987 Deterioration (GPR)
- 1988 Deterioration (GPR)



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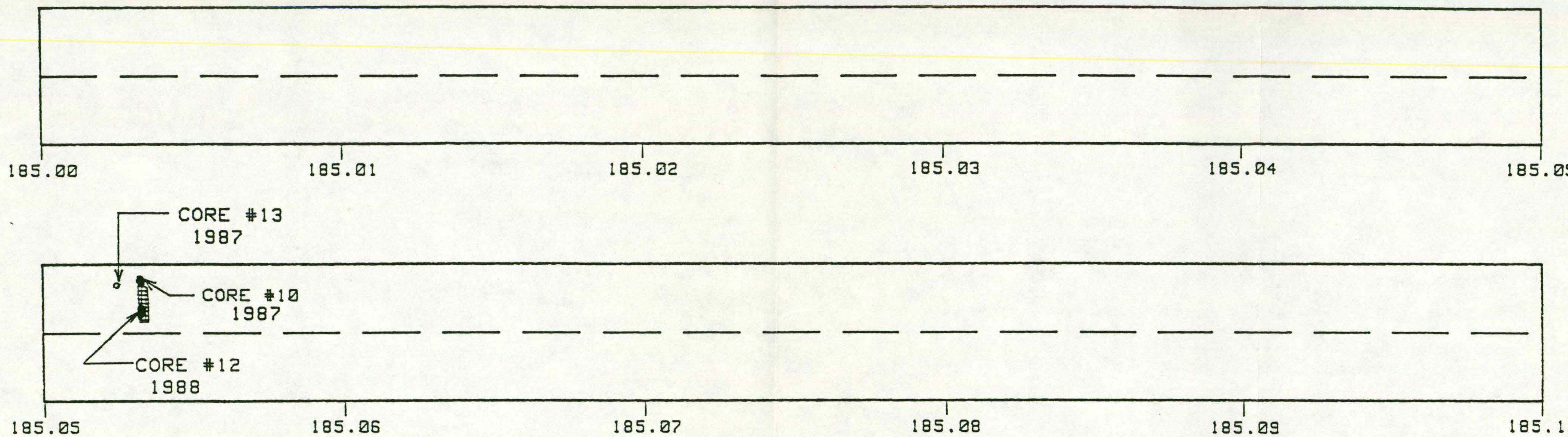
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (WESTBOUND)STA 184.00 TO STA 184.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	WESTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	2 (sq.ft.)
Concrete Patch	11 (sq.ft.)
Deterioration (GPR)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

Debond (IR)
1987 Concrete Patch
1988 Concrete Patch
1987 Deterioration (GPR)
1988 Deterioration (GPR)

0' 10' 20'

N

Donohue
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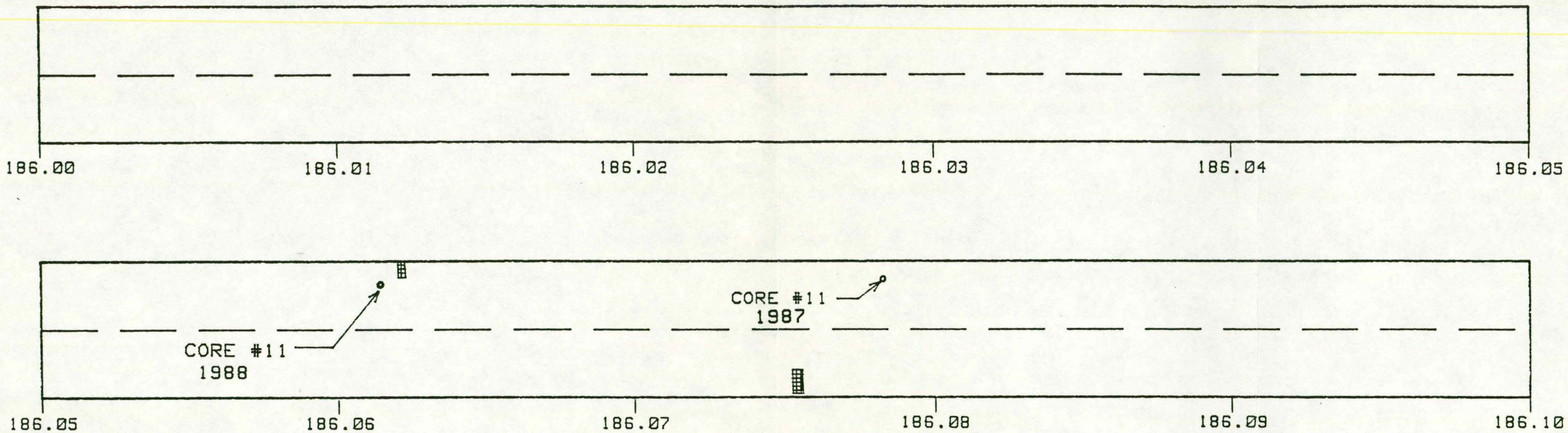
IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (WESTBOUND)STA 185.00 TO STA 185.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	WESTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	11 (sq.ft.)
Deterioration (GPR)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

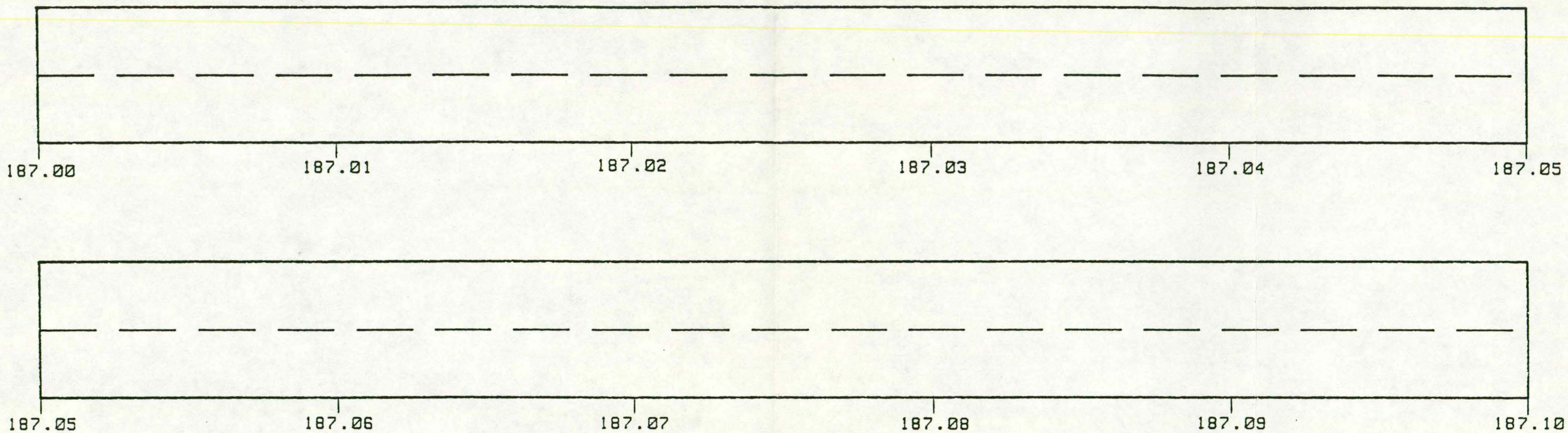
- Debond (IR)
- 1987 Concrete Patch
- 1988 Concrete Patch
- 1987 Deterioration (GPR)
- 1988 Deterioration (GPR)

0' 10' 20'

N

Donohue
Engineers & Architects

IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (WESTBOUND)STA 186.00 TO STA 186.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	WESTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	None (sq.ft.)
Deterioration (GPR)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

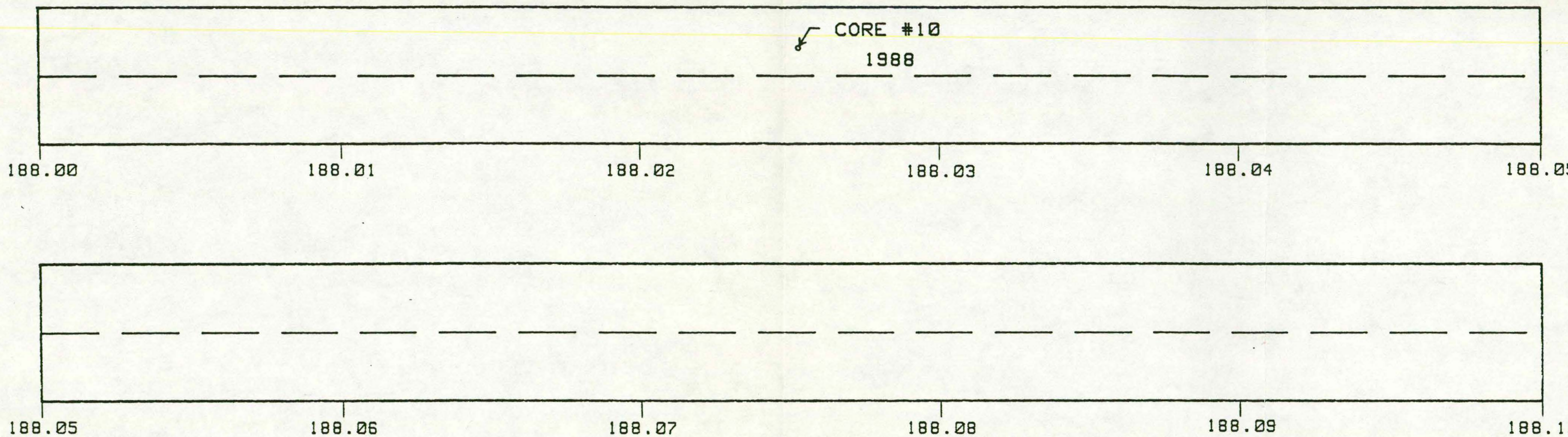
- Debond (IR)
- 1987 Concrete Patch
- 1988 Concrete Patch
- 1987 Deterioration (GPR)
- 1988 Deterioration (GPR)

0' 10' 20'

N

Donohue
Engineers & Architects

IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (WESTBOUND)STA 187.00 TO STA 187.10
IOWA DEPARTMENT OF TRANSPORTATION



AREAS	WESTBOUND LANES
Total Area	12,672 (sq.ft.)
Debond (IR)	None (sq.ft.)
Concrete Patch	None (sq.ft.)
Deterioration (GPR)	None (lin.ft.)

Inspection Date: August, 1987
August, 1988

LEGEND

Debond (IR)
1987 Concrete Patch
1988 Concrete Patch
1987 Deterioration (GPR)
1988 Deterioration (GPR)

0' 10' 20'

N

PAGE 15 OF 15

Donohue
Engineers & Architects

IR AND GPR EVALUATION OF BOND RETAINAGE
IN PORTLAND CEMENT CONCRETE OVERLAYS
I-80 (WESTBOUND)STA 188.00 TO STA 188.10
IOWA DEPARTMENT OF TRANSPORTATION