WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIAL CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

METHOD OF TEST FOR DETERMINING THE CONDITION OF CONCRETE BRIDGE DECKS

1. PURPOSE

1.1. To provide a method of testing to determine the condition of concrete bridge decks.

2. SCOPE

2.1. This procedure is applicable to concrete bridge decks.

3. REFERENCE DOCUMENTS

3.1. ASTM C39: Test Method for Compressive Strength of Cylindrical Concrete Specimens

3.2. ASTM C42: Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

3.3. ASTM C876: Standard Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete

3.4. ASTM C1152: Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete

3.5. ASTM D4580: Standard Practice for Measuring Delamination in Concrete Bridge Decks by Sounding

3.6. ASTM D6432: Standard Guide for Using the Surface Ground Penetrating Radar Method for Subsurface Investigation

3.7. ASTM E11: Standard Specifications for Woven Wire Test Sieve Cloth and Test Sieves

3.8. AASHTO T-260: Standard Method of Test for Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials

4. EQUIPMENT

4.1. Chain Drag Test

4.1.1. Chains, steel rods, or hammers capable of producing a clear ringing sound when dragged or tapped over non-delaminated concrete and a dull or hollow sound over delaminated concrete.

4.1.2. Measuring tape capable of measuring 150 to 300 ft.

4.1.3. Measuring tape capable of measuring 12 to 25 ft.

4.1.4. Chalk for marking delaminated areas.

4.2. Potential Corrosion Test

4.2.1. Potential corrosion meter capable of generating the data required to produce the report seen in Section 11 of ASTM C876.

4.2.2. Minimum 2-gallon container of distilled water, free of contaminates.

4.2.3. Handheld rebar detector capable of locating rebar embedded in concrete at a minimum depth of 7 inches.

4.3. Core Sampling

4.3.1. Core drill capable of obtaining cylindrical core specimens through steel reinforced concrete.

4.3.2 4 in. diameter diamond impregnated drill bit.

4.3.3 Saw capable of trimming ends of cores and sectioning cores into 1 in. high cylindrical specimens. This saw shall be capable of cutting cores without introducing cracks or dislodging aggregate particles. Ensure cores are properly stabilized using core holders to prevent movement during sawing.

4.3.4 A grinder or pulverizer capable of grinding concrete and aggregate material fine enough to pass through an 850-µm (No. 20) sieve.

4.3.5 850-µm (No. 20) sieve complying with ASTM E11.

4.3.6 Containers capable of maintaining samples in an uncontaminated state.

4.4 Crack Mapping

4.4.1 Measuring tape capable of measuring 150 to 300 ft.

4.4.2 Measuring tape capable of measuring 12 to 25 ft.

4.4.3 Crack width gauge

4.5 Ground Penetrating Radar

4.5.1 A transmitter and receiver antenna in compliance with ASTM D6432

4.5.2 A radar control unit in compliance with ASTM D6432

4.5.3 Suitable data storage and display devices in compliance with ASTM D6432

5. PROCEDURE

5.1. The bridge deck and all lanes should be surveyed before beginning tests to create a plan of action and ensure the safest approach with traffic control.

5.2. Chain Drag Test

5.2.1. Run the 150 to 300 ft measuring tape longitudinally along bridge, repositioning if bridge length exceeds tape length

5.2.2. Drag chains over the entirety of the deck surface. Delaminated areas produce a dull or hollow sound. Any detected delaminated areas shall be outlined using chalk.

5.2.3. Using a 12 to 25 ft. measuring tape, locate the exact location and record delaminated area on grid paper seen in Attachment 3.

5.3. Potential Corrosion Test

5.3.1. Unpack and assemble the concrete corrosion potential meter.

5.3.2. Unscrew the top of the reference electrode and add sufficient copper sulphate crystals into the tube. Fill the tube with distilled water, cap and shake to mix. Ensure the mixture is in a supersaturated state by adding enough copper sulphate to have undissolved crystals after shaking.

5.3.3. Connect the electrode to the meter by pressing the adapter plate onto the bottom of the LC-4.5, securing it with Velcro pads. Screw the 15 in. intermediate electrode extension into the threaded receptacle on the adapter plate. Add more extensions until the meter is at comfortable height, reaching from the ground to the hands of the operator.

5.3.4. Plug the adaptor plate pigtail into the negative (black) terminal on the meter.

5.3.5. Place the function switch of the LC-4.5 meter to the DC position. Place the range selector switch to the 2V scale. Place the input resistance selector switch to the 200 meg-ohm position.

5.3.6. Clamp the vice-grip pliers onto any exposed rebar on the bridge, or a metal expansion dam, and clip one end of the 250-foot test lead to the pliers. Plug the end of the lead into the positive (center, red) terminal on the LC-4 meter.

5.3.7. This connection must be made to either an exposed rebar or a metal expansion dam on the bridge. When an access shaft is needed to expose the embedded steel; a rebar detector shall be used to locate rebar; and a minimum 4’’ core shall be drilled to the depth of the reinforcement without cutting the rebar. A minimum 1 in. area of the epoxy coating on the epoxy coated rebar will need to be removed for the entire clamp to be in contact with the rebar.

5.3.8. Place the reference electrode assembly against the prepared location on the concrete surface adjacent to the marked spot. If the electrical connection to the rebar is good, and the concrete and interface sponge are wet enough, a steady reading (measurement) between -0.010V and -0.600V should be obtained on the meter within 3-5 seconds. A slight variation in the last digit (thousandth place) can be normal. If the test setup is working satisfactorily, it should be possible to go back to a location and obtain an identical reading within ± 0.020V of the original reading.

5.3.9. Placing tape measures longitudinally and laterally, lay out a grid of the test location covering the entire area which is to be tested. (Tests do not have to be made directly over the rebars).

5.3.10. Take potential readings every 3 ft. by 3 ft. over the entire bridge deck. The sponge contacting the electrode must be kept moist during the entire test.

5.3.11. Record the results of each reading on the grid paper in Attachment 4.

5.3.12. Results generated shall be presented according to Section 9 of ASTM C876.

5.4. Core Samples

5.4.1. Compressive Strength Test

5.4.1.1. At least 1 location per lane shall be selected to obtain compressive strength cores. If the bridge deck only contains 1 lane of traffic, at least 2 locations shall be selected to obtain compressive strength cores. The chosen location should avoid the wheel path of traffic and permit the retrieval of the core underneath the bridge. The selected location will not be over the support beams of the bridge. The cores should be 4 in. diameter and the entire thickness of the bridge deck.

5.4.1.2. Each core shall be labeled with its core number, bridge name, route, lane type, and direction of traffic. Locations of cores shall be mapped per Attachment 5.

5.4.1.3. MCS&T shall coordinate with the District to have any core holes repaired.

5.4.1.4. Once the cores are obtained, using diamond impregnated bits, the compressive strength should be tested following the procedures of ASTM C42 and ASTM C39

5.4.2. Chloride Content

5.4.2.1. At least 1 location per lane shall be selected to obtain cores for chloride testing. The chosen location should avoid the wheel path of traffic and permit the retrieval of the core underneath the bridge. The selected location will not be over the support beams of the bridge. The cores should be 4 in. diameter and the entire thickness of the bridge deck. Each core shall be labeled with its core number, bridge name, route, lane type, and direction of traffic. Locations of cores shall be mapped per Attachment 5.

5.4.2.2. MCS&T shall coordinate with the District to have any core holes repaired.

5.4.2.3. Cores obtained in the field in 5.4.2.1 will be cut into one (1) in. thick disc specimens maintaining their four (4) in. diameters once received in the laboratory. Successive (1) in. sections will be cut from the core starting with the section that represents the top surface of the bridge deck to the bottom approximately at a depth of 8.0 inches. Each section will be labeled with the core number and depth.

5.4.2.4. Each 1 in. cylindrical slice shall be pulverized individually into material fine enough to pass through a 850-µm (No. 20) sieve and placed into its own individual container. Do not mix or contaminate the sample with material from another sample disc. Each individual container should be labeled with the core number and the depth it represents.

5.4.2.5. The concrete dust in the labeled sample container will be tested for chloride content following Sections 9 and 10 of ASTM C1152.

5.4.2.6. Record the test results in the format of the table in Attachment 8.

5.5. Crack Mapping

5.5.1.1. Walk the entire area of the bridge deck looking for any cracks, longitudinally and transversely.

5.5.2. Using a tape measure, record the location and length of each crack on the grid paper in Attachment 3.

5.5.3. Using a crack width gauge, record the average width of each crack on the grid paper in Attachment 3.

5.6. Ground Penetrating Radar

5.6.1. A Ground Penetrating Radar investigation may be requested on a bridge deck; it shall be run according to ASTM C6432.

6. CALCULATIONS

6.1. Chain Drag Test

6.1.1. The total area of delamination, spalls, and patched shall be calculated against the total area of the bridge deck. Refer to Attachment 5 for example.

6.2. Potential Corrosion Test

6.2.1. The total area of potential readings greater than -0.20V shall be calculated against the total area of the bridge.

6.2.2. The total area of the potential readings in the range of -0.20V to -0.35V shall be calculated against the total area of the bridge.

6.2.3. The total area of potential readings less than -0.35V shall be calculated against the total area of the bridge.

6.2.4. Potentials greater than -0.20V indicate a 90% or higher probability of no corrosion taking place at the time of measurement.

6.2.5. Potentials in the range of -0.20V to -0.35V are inconclusive.

6.2.6. Potentials less than -0.35V generally indicate a 90% or higher probability of active corrosion taking place at the time of measurement. Refer to Attachment 8 for example.

6.3. Compressive Strength Cores

6.3.1. The compressive strength of the cores shall be calculated according to ASTM C39

6.4. Crack Mapping

6.4.1. The total area of cracks shall be calculated against the total area of the bridge. Refer to Attachment 6 for example.

7. REPORTING

7.1. The results will be presented through a Materials Inspection Report (MIR) by an official Memorandum. An example Memorandum and MIR can be found in Attachments 1 and 2.

7.2. The MIR shall include the following sections: Introduction, Accounting Data, Purpose of Report, Results of Bridge Deck Condition Survey, Conclusion, and

Recommendations. In additions Attachments 5-9 shall be completed and provided as attachments with the MIR.

Michael Mance

Digitally signed by Michael Mance
Date: 2025.07.15 14:20:59 -04'00'

Michael A Mance, PE
Director
Materials Control, Soils & Testing Division

MAM:Tk
MP 601.00.49 Steward – Cement and Concrete Section
ATTACHMENT

Example

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION

Division of Highways

1900 Kanawha Boulevard East • Building Five • Room 110
Charleston, West Virginia 25305-0430 • (304) 558-3505

Deputy Secretary of Transportation
Deputy Commissioner of Highways

Secretary of Transportation
Commissioner of Highways

MONTH DAY, XXXX

M E M O R A N D U M

TO: **NAME**
DISTRICT CONSTRUCTION ENGINEER
DISTRICT NUMBER

FROM: **NAME**
DIRECTOR
MATERIALS CONTROL, SOILS AND TESTING DIVISION

THRU: **HF**

SUBJECT: **BRIDGE DECK CONDITION SURVEY**
BRIDGE NUMBERS:
BARS NUMBERS:
BRIDGE NAME, COUNTY, DISTRICT NUMBER

Attached for your review and further handling is a copy of Materials Inspection Report (MIR) Number XXXXXXX. This MIR documents our findings regarding the subject bridge and will serve as a bridge deck condition survey.

Should you have any questions, please feel free to contact NAME at XXX-XXX-XXXX.

MAM:Td

Attachment

CC: (District Bridge Engineer, Regional Construction Engineer)

Example

Materials Inspection Report:	XXXXXXX
Authorization Number:	XXXXXXX
Subject:	Bridge Deck Condition Survey
BARS Number:	
County:	
District:	
Date of Report:	Month Day, Year

1. **ACCOUNTING DATA**

1.1 Project Name:

State Project No.: Contract ID: XXXXXXXXXX

Federal Project No.: Authorization No.:

ORG No.:

2. **INTRODUCTION**

2.1 As requested in MONTH of YEAR by the District NUMBER Regional Construction Engineer, a bridge deck condition survey was performed beginning on MONTH DAY, YEAR, and was concluded on MONTH DAY, YEAR. The tests that were performed were as follows: chain drag test, crack mapping, compressive strength cores, chloride core content and corrosion potential.

3. **PURPOSE OF REPORT**

3.1 This report provides the data developed regarding the bridge deck condition.

4. **RESULTS OF BRIDGE DECK CONDITION SURVEY**

4.1 Surface Condition

4.1.1 The bridge deck surfaces exhibited spalling and delamination.

4.2 Subsurface Condition

4.2.1 The bridge deck subsurface condition survey was not performed because it was not requested.

4.3 Delamination Survey (ASTM D-4580)

4.3.1 The chain drag test was used to locate subsurface delamination in the bridge deck. Bridge number ________ was found to have delamination affecting ___% of the entire bridge deck. Bridge number ________was found to have delamination affecting _____% of the entire bridge deck.

4.3.2 See Attachment No. 6 for the plotted delamination of the bridge decks.

4.4 Bridge Deck Surface Cracking

4.4.1 The transverse and longitudinal cracks were measured and mapped. Bridge number _________ was found to have cracking on _____% of the bridge deck. Bridge number ______ was found to have surfacing cracking on ____% of the bridge deck. The transverse and longitudinal crack widths ranged from ____ to ____ throughout the top surface of the deck.

4.4.2 See Attachment No.6 for the plotted locations of the concrete cracks on the bridge deck.

4.5 Compressive Strength Cores (ASTM C39).

4.5.1 _____ compressive cores were taken in total. _____bridge cores were used to determine the compressive strength of the deck.

4.5.2 Results from northbound and southbound lanes:

Core	NB-F-2	NB-S-4	SB-SL-C1	SB-FL-C4
Length (in.)	5.428			
Diameter 1 (in.)	3.982			
Diameter 2 (in.)	3.997			
Correction Factor	0			
Load (lbs.)	95240			
Force (psi)	7579			
Break Type	D,E etc…..			

Average Force (psi)	psi

4.5.3 The depth of the overlay, from each of the ___ cores, was measured using visual indications of the different concrete layers:

NB-F-1	NB-F-2	NB-S-3	NB-S-4	SB-SL-1	SB-SL-2	SB-FL-3	SB-FL-4

2.5in.							

4.5.4 See Attachment No. 3 for the visual locations and a photograph of each core.

4.6 Chloride Content of Bridge Deck Concrete (AASHTO T-260)

4.6.1 ____, one-inch layers where cut from the cored cylinders to determine the Chloride Content of the Bridge Deck. The one-inch layers were cut from four of the ____, compressive strength cylinders. ______of the one-inch layers in the northbound cores were unable to be chloride tested because the presence of rebar compromised their ability to hold during the slicing process.

4.6.2 Results from northbound and southbound lanes:

Core Number	Location of Sample on Core	Lbs./yd^3
NB-F-1 (Lab No.)	0.5 – 1.5 inches from bottom	0.8
	1.5 – 2.5 inches from bottom	
	2.5 – 3.5 inches from bottom	
	3.5 – 4.5 inches from bottom	
	4.5 – 5.5 inches from bottom	
	5.5 – 6.5 inches from bottom	
	6.5 – 7.5 inches from bottom	
	Average for Cylinder	1.25
NB-S-3 (Lab No.)	0.5 – 1.5 inches from bottom	
	1.5 – 2.5 inches from bottom	
	2.5 – 3.5 inches from bottom	
	3.5 – 4.5 inches from bottom	
	4.5 – 5.5 inches from bottom	
	5.5 – 6.5 inches from bottom	
	6.5 – 7.5 inches from bottom	
	Average for Cylinder	

SB-Sl-C2 (Lab No.)	0.5 – 1.5 inches from bottom	
	1.5 – 2.5 inches from bottom	
	2.5 – 3.5 inches from bottom	
	3.5 – 4.5 inches from bottom	
	4.5 – 5.5 inches from bottom	
	5.5 – 6.5 inches from bottom	
	6.5 – 7.5 inches from bottom	
	Average for Cylinder	
SB-FL-C3 (Lab No.)	0.5 – 1.5 inches from bottom	
	1.5 – 2.5 inches from bottom	
	2.5 – 3.5 inches from bottom	
	3.5 – 4.5 inches from bottom	
	4.5 – 5.5 inches from bottom	
	5.5 – 6.5 inches from bottom	
	6.5 – 7.5 inches from bottom	
	Average for Cylinder	

4.6.3 The average chloride content for each layer across these four cylinders are:

Location of Sample on Core	Lbs./yd^3
6.5 – 7.5 inches from bottom	0.8
5.5 – 6.5 inches from bottom	1.2
4.5 – 5.5 inches from bottom	1.2
3.5 – 4.5 inches from bottom	1.4
2.5 – 3.5 inches from bottom	2.0
1.5 – 2.5 inches from bottom	0.8

0.5 – 1.5 inches from bottom	0.8

4.6.4 As expected, the middle layers have the highest chloride content because these layers were exposed on the surface before it was overlayed. However, the data in the overlay layers suggest a higher chloride content than when the concrete was originally placed. With data missing from the higher layers due to the rebar interference, it is predicted that the overlayed surface layer should have a more consistent chloride content with the surrounding layer

4.7 Corrosion Potential of Uncoated Reinforcing Steel in Bridge Deck (ASTM C876)

4.7.1 The corrosion potential was determined by measuring the potential difference between a reference electrode and embedded steel. In this case, the meter was connected to the steel beam beneath the concrete bridge. The corrosion potentials are documented every 3 feet longitudinally and laterally.

4.7.2 Potentials less negative than -0.20V generally indicate a 90% or higher probability of no corrosion taking place at the time of measurement. Potentials in the range of -0.20V to -0.35V are inconclusive. Potentials greater than -0.35V generally indicate a 90% or higher probability of active corrosion in the area at the time of testing.

4.7.3 Bridge number (NB) was found to have a ___% or higher probability of corrosion on ____% of the bridge deck. Bridge number ______ (SB) was found to have a ___% or higher probability of corrosion on ___% of the bridge deck.

4.7.4 See Attachment No. 9 for the plotted corrosion potentials found on the bridge decks.

5. **CONCLUSION**

5.1 The bridge deck condition survey revealed delamination in the bridge deck concrete to the depth of the top line of reinforcing steel in the bridge deck. The bridge deck concrete did exhibit transverse and longitudinal cracking. The bridge deck concrete did exhibit the probability of steel corrosion. The bridge deck concrete did exhibit an increase in chloride content closer to the surface.

6. **RECOMMENDATIONS**

6.1 Due to the severity and extent of damage found during the bridge deck condition survey, replacement of the deck overlay is recommended.

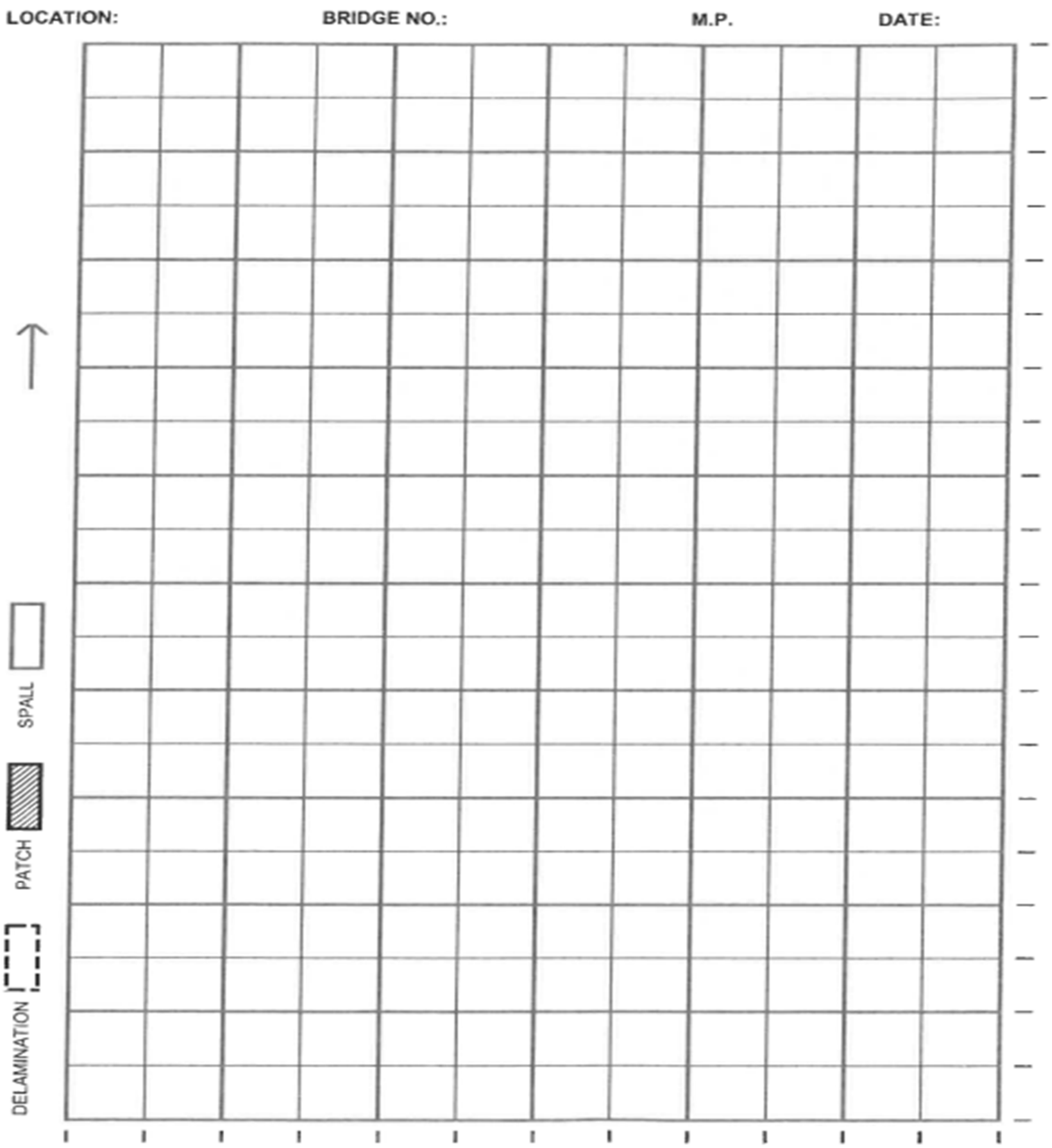
____

Signature
Cement and Concrete Section

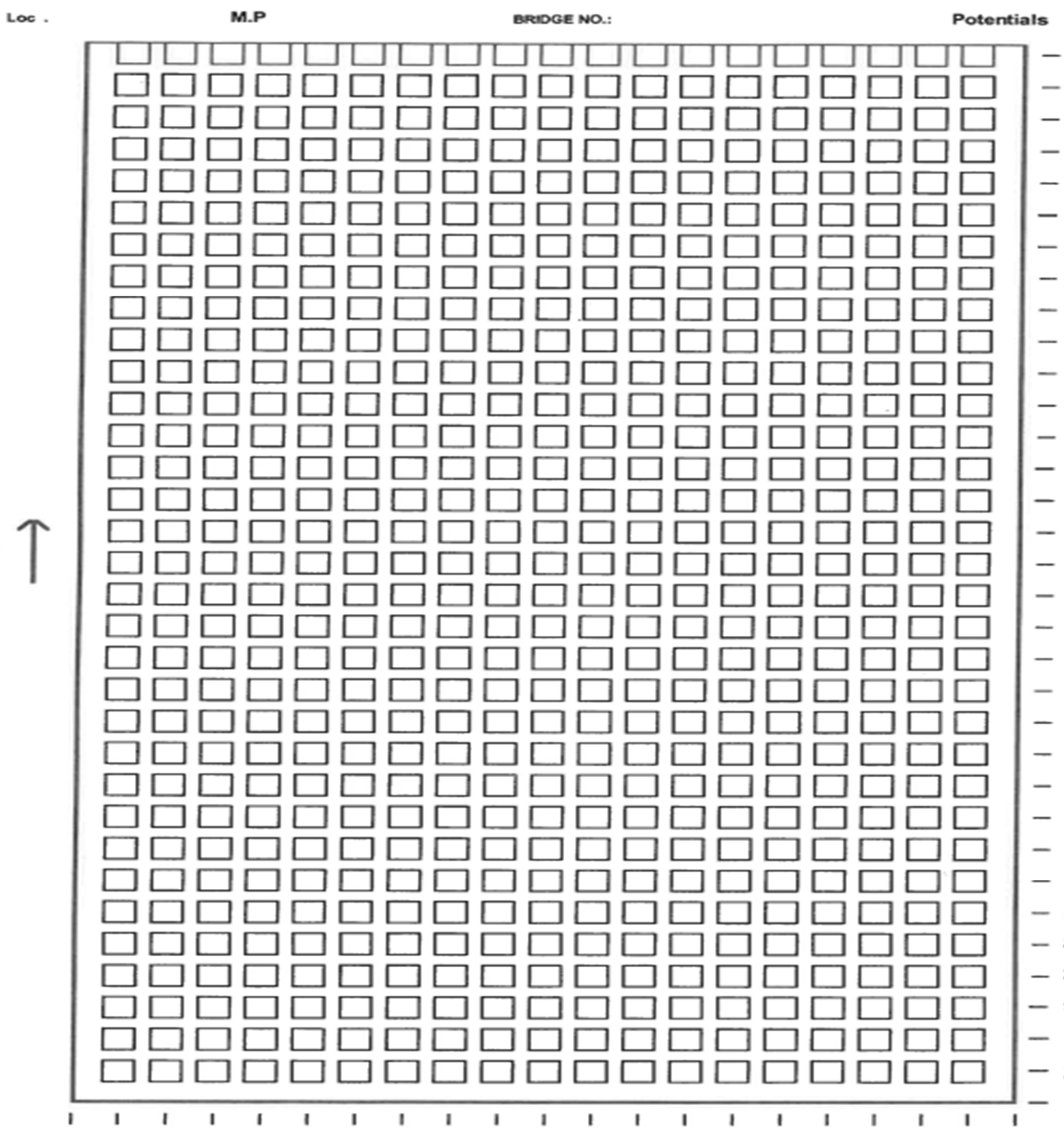
____

Signature
Cement and Concrete Section Supervisor

Field Defect Map

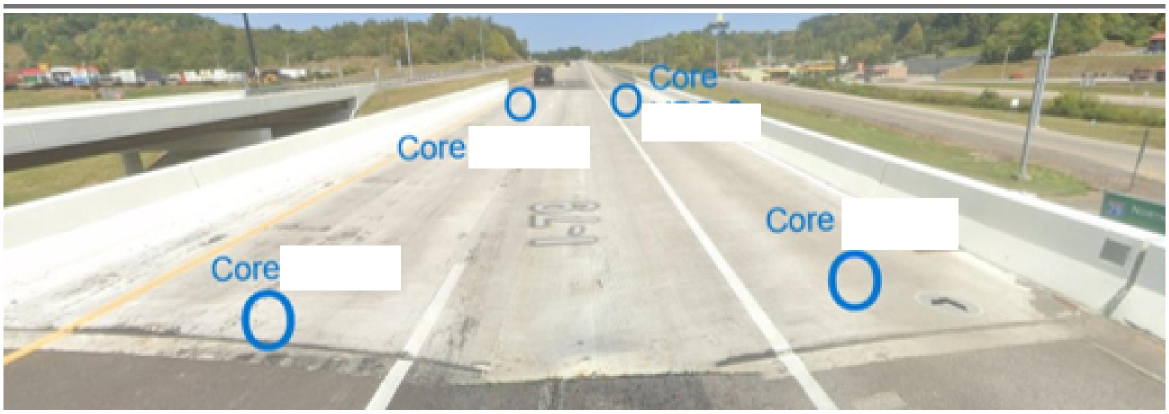


Field Corrosion Potential Map

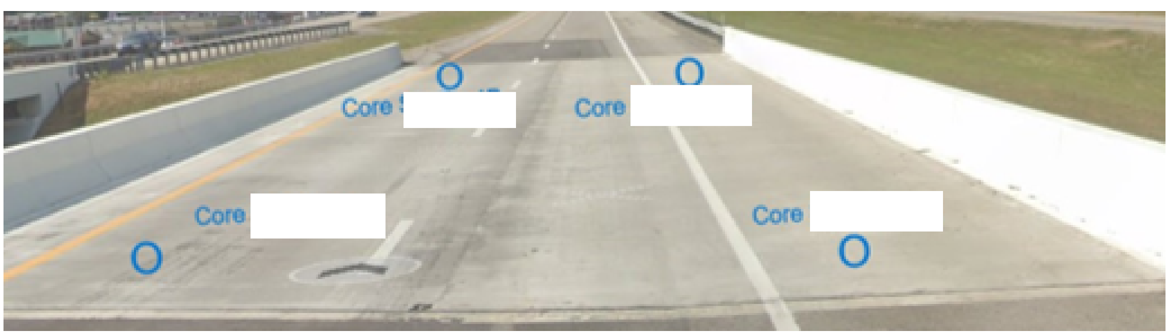


Core Loaction Maps

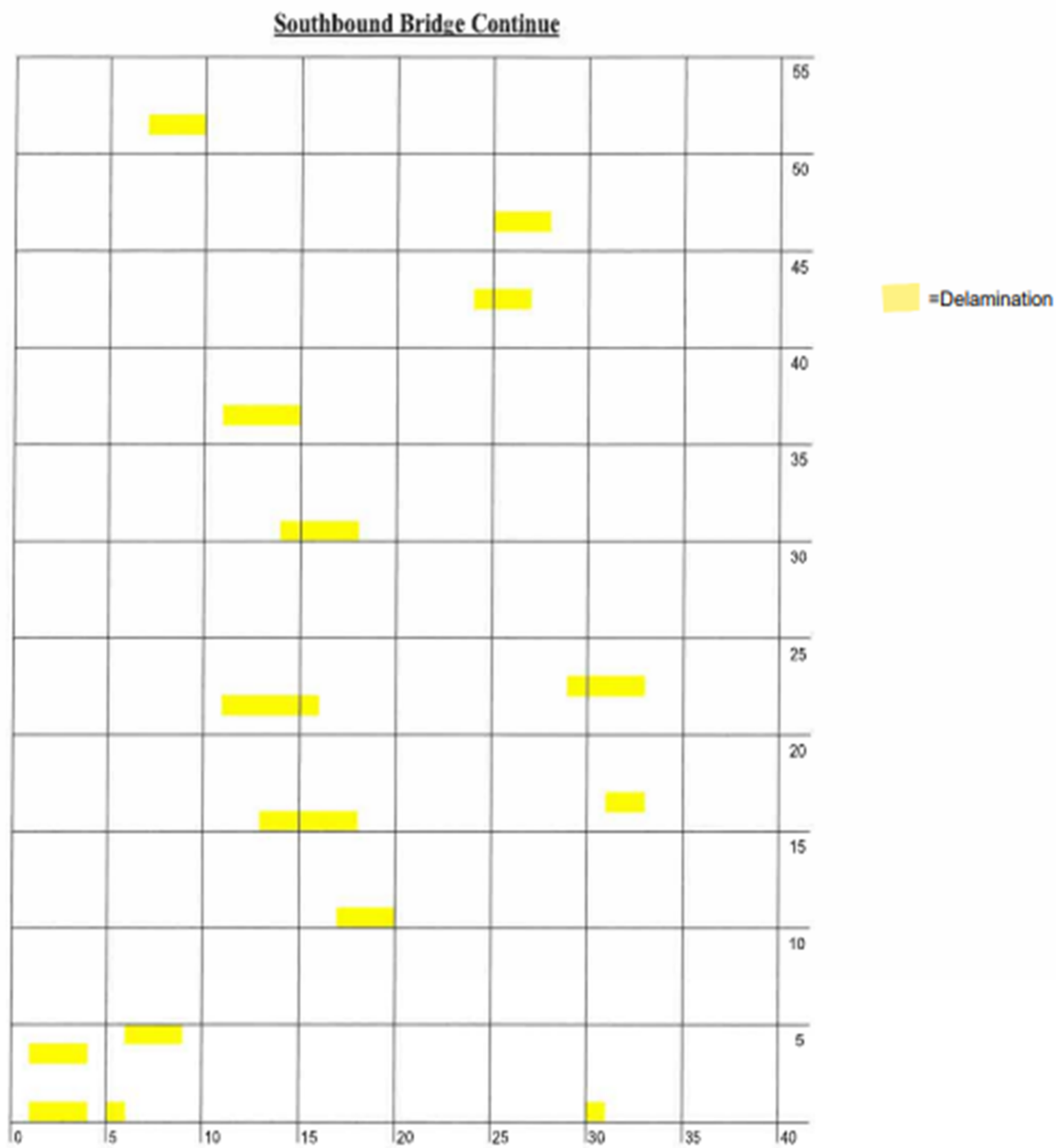
Northbound Core Locations



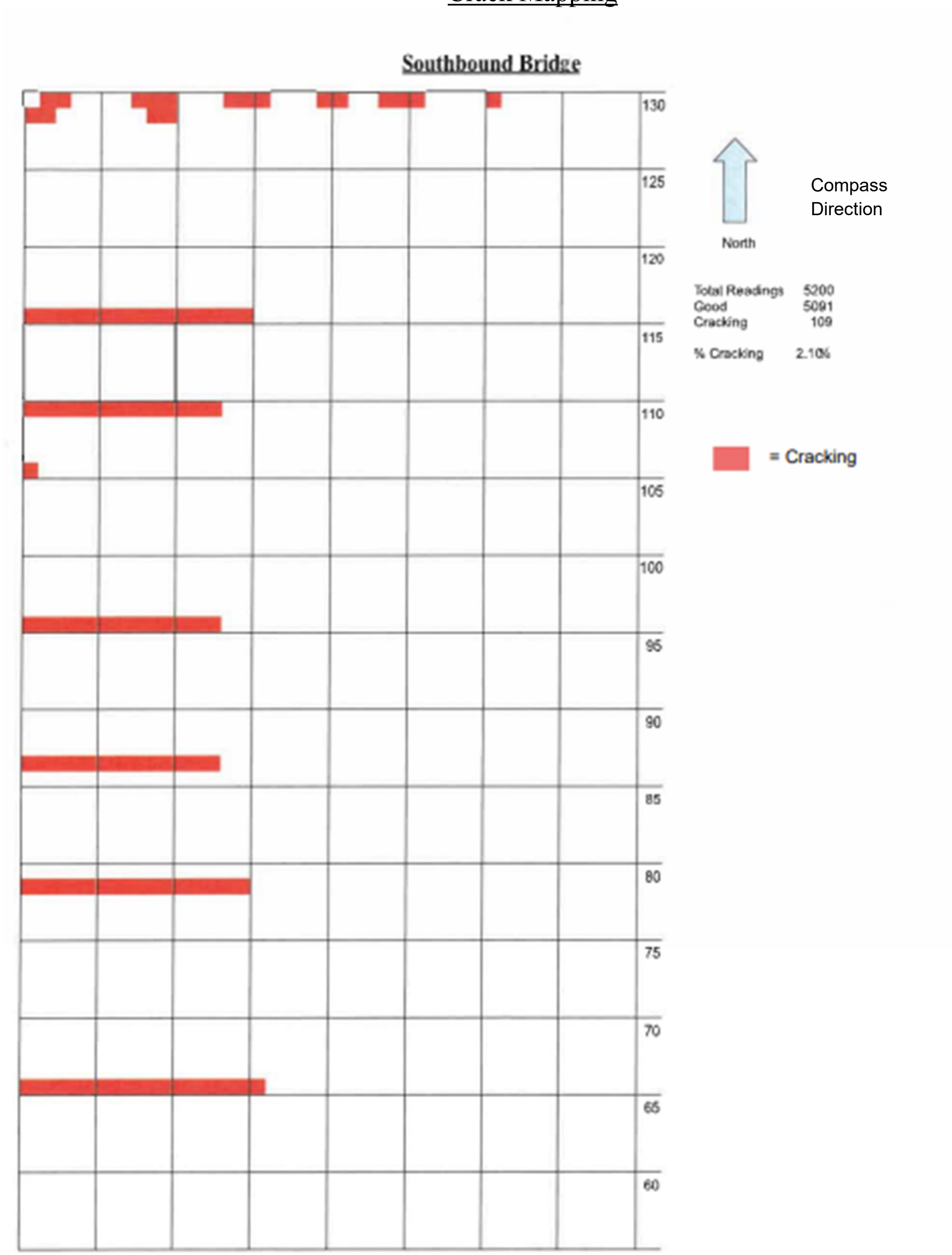
Southbound Core Locations



Delamination Plotting



Crack Mapping

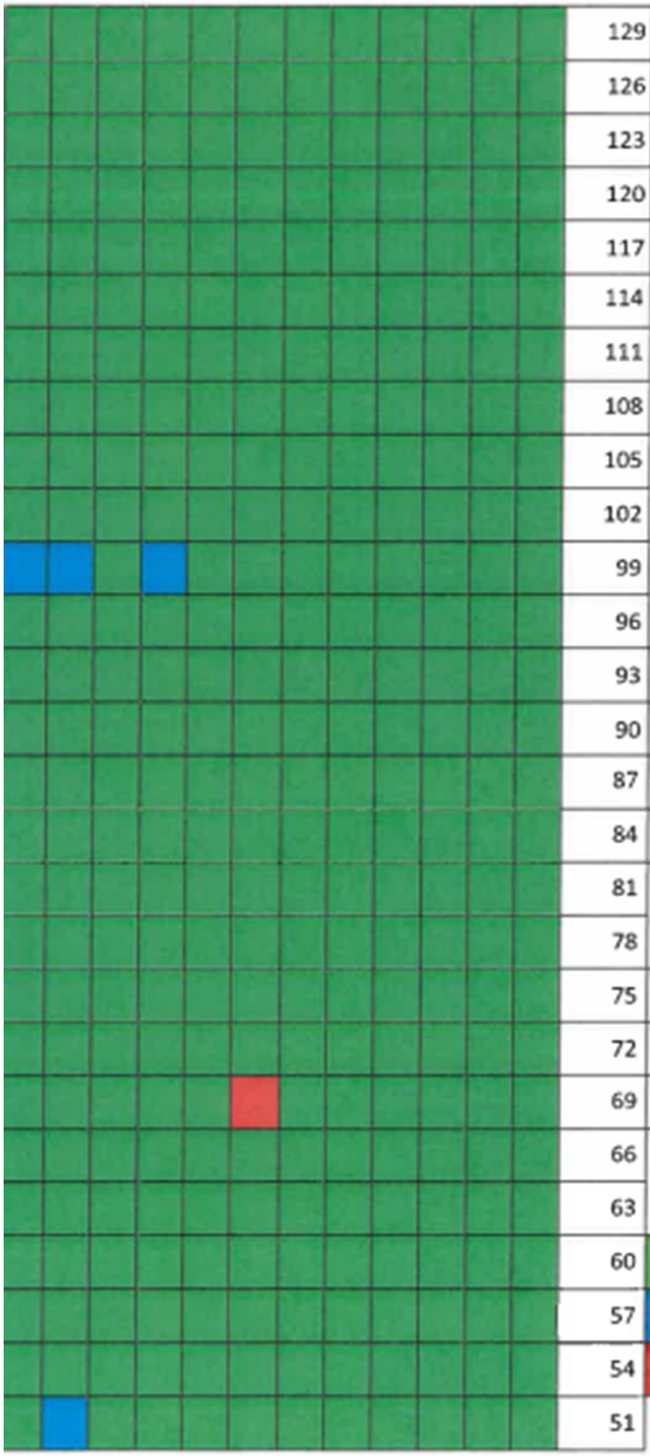


Chloride Content Results Table

Core #	Depth in inches	lbs. of Chloride per CY of Concrete
C1	0.5 to 1.5	3
C1	1.5 to 2.5	1
C1	2.5 to 3.5	0
C1	3.5 to 4.5	0
C1	4.5 to 5.5	0
C1	5.5 to 6.5	0
C2	0.5 to 1.5	0
C2	1.5 to 2.5	0
C2	2.5 to 3.5	0
C2	3.5 to 4.5	0
C2	4.5 to 5.5	0
C2	5.5 to 6.5	0
C2	6.5 to 7.5	2
C3	0.5 to 1.5	2
C3	1.5 to 2.5	1
C3	2.5 to 3.5	1
C3	3.5 to 4.5	0
C3	4.5 to 5.5	1
C3	5.5 to 6.5	0
C4	0.5 to 1.5	2
C4	1.5 to 2.5	1
C4	2.5 to 3.5	1
C4	3.5 to 4.5	0
C4	4.5 to 5.5	0
C4	5.5 to 6.5	0
C4	6.5 to 7.5	0

Corrosion Potential Map

Northbound Bridge



Measured Potential	Amount
> (-0.20 V)	508
< (-0.35 V)	1
< (-0.20 V) and > (-0.35 V)	7
Total Readings	516

Probability of Steel Corrosion	Measured Potential
Less than 10%	> (-0.20 V)
Uncertain	< (-0.20 V) and > (-0.35 V)
More than 90%	< (-0.35 V)

Measured Potential	% Found in Bridge
> (-0.20 V)	98%
< (-0.20 V) and > (-0.35 V)	1%
< (-0.35 V)	0.2%