OSBORNE BRIDGE
2009 CONDITION SURVEY
Winnipeg, Manitoba

Prepared For:
WARDROP ENGINEERING INC.
400-386 Broadway P.O. Box 5000
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October 14, 2009 Project No. 09-571

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SITE LOCATION OF OSBORNE BRIDGE

October 14, 2009
TBTE Ref. No. 09-571

Vaivhab Banthia
Wardrop Engineering Inc.
400-386 Broadway
Winnipeg, MB
R3C 4M8

Dear Mr. Banthia,

Re: Osborne Bridge
Condition Survey

1.0 INTRODUCTION

TBT Engineering Limited (TBTE) was retained by Wardrop Engineering Inc. to undertake a condition survey and laboratory testing program for the Osborne Street Bridge in Winnipeg. The bridge deck of the structure consist of a concrete slab covered by an asphalt pavement.

2.0 SCOPE OF WORK

Fieldwork for this project started on August 31 and was completed on September 18, 2009. The traffic control was provided by Guardian Traffic Services Manitoba while the underside bridge crane used during investigation of the substructure was provided by the City of Winnipeg. The scope of work completed consisted of the following:

a) asphalt pavement sawn sample removal from the bridge deck and inspection of the exposed concrete surface
b) recovery of concrete core samples from the bridge deck and substructure for compressive strength testing, chloride content and air-void parameters in hardened concrete
c) corrosion potential survey
d) laboratory testing of core samples for compressive strength testing
e) laboratory testing of core samples for chloride content
f) laboratory testing of core samples for air-void parameters in hardened concrete

3.0 SUMMARY OF SIGNIFICANT FINDINGS

3.1 Asphalt Pavement Sawn Sample

A total of 12 asphalt sawn samples, approximately 250 mm by 250 mm in size, were recovered from the bridge deck to expose the concrete deck surface. The samples were removed by dry sawing to avoid intrusion of water onto the concrete surface. The asphalt pavement thickness was measured and recorded. Sample locations, detailed comments and photographs are provided in Appendix A.

The exposed concrete for each hole was inspected for evidence of concrete deterioration. A hammer survey technique was used to determine if the exposed concrete surface was delaminated. Since the concrete deck was covered by asphalt pavement, delamination survey using a chain drag was not performed.

No evidence of moisture was observed in the surface of the concrete deck beneath the asphalt pavement. Concrete distress in the form of delamination and cracking was observed at the sawn locations in the north bound curb lane (Sawn Sample No. 1 to 3) and at one location at the northbound median lane (Sawn Sample No. 7). It was observed that the bottom surface of the asphalt samples recovered from these locations were covered with approximately 15 to 20% concrete from the underlying deck ranging from 5 to 15 mm in depth. Sound concrete surfaces were observed after removal of asphalt pavement sawn samples from the southbound lanes of the bridge deck. The thickness of the asphalt pavement taken during pavement sawing ranged from 52 to 91 mm with an average value of 73 mm. The depths of concrete cover over the reinforcing steel at these locations ranged from 38 to 49 mm with an average value of 44 mm.

3.2 Concrete Compressive Strength Testing

Four concrete cores were taken from the bridge deck and three cores were obtained from the piers. Details of the core locations, compressive strength data and photographs are provided in Appendix B.

The cores were trimmed and tested for compressive strength in accordance with CSA A23.2-14C, Obtaining and Testing Drilled Cores for Compressive Strength Testing. Two cores were taken from the southbound lane deck and two cores were taken from the northbound lane. As requested, a full depth core (Core No. 15) was recovered from the northbound lane to confirm the total thickness of the concrete deck. The total thickness of the full depth core was determined to be 188 mm. The average compressive strength for the cores taken from the northbound lane was determined to be 40 MPa, while the average compressive strength results for the cores taken from the southbound lane was determined to be 63 MPa.

These compressive results are consistent with our findings based upon the sawn samples that concrete distress is more evident in the northbound lane compared with the southbound lane.

The compressive strength results obtained from the cores taken from the piers ranges from 52 to 66 MPa with an average value of 58 MPa.

3.3 Chloride Analysis

Nine concrete core samples were obtained from the bridge deck and one core sample was taken from the south abutment seat substructure. The test results for the chloride analyses and locations where the core samples were recovered are provided in Appendix C.

The samples were tested for water-soluble chloride content in accordance with CSA A23.2-4B.

Tests for chloride content from the deck were conducted from 10 mm slices cut from the cores at the following depths:

a) 20 to 30 mm
b) 50 to 60 mm
c) 70 to 80 mm
d) 90 to 100 mm

Two further chloride content tests were conducted in the deck at a depth between 100 and 150 mm below the concrete surface to establish the background chloride content of the concrete.

For the core sample taken from the abutment seat substructure, concrete slices were taken and tested at depths of 10 to 20 mm, 30 to 40 mm, and 50 to 60 mm below the concrete surface.

The chloride content by mass of cement was calculated based upon the average concrete density of 2320 kg/m^3 obtained from the cores and an estimated cement content of 340 kg/m^3.

The chloride threshold value necessary to depassivate embedded steel and permit corrosion in the presence of oxygen and moisture is usually taken to be 0.15% by mass of cement. To verify whether sufficient chloride has affected the concrete to cause corrosion of the embedded rebar, it is necessary to correct the test results for the background chloride content. Background chloride which is measured by the test method but does not contribute to corrosion was deducted from all chloride content test results. Based upon the test results for the core samples, a background chloride content of 0.048% by mass of cement was used to calculate the corrected water-soluble chloride contents.

The chloride content results obtained from core slices taken at 20 to 30 mm depth and one slice from 30 to 40 mm exceeded the threshold value (0.157 to 1.030%). With one exception, the chloride contents below the 30 mm level were lower than the threshold value of 0.15% by mass of cement. This is consistent with the indication of little corrosion given by the half-cell potential and corrosion rate readings.

The chloride content obtained from the core sample taken from the south abutment seat (Core No. 10) significantly exceeded the threshold value of 0.15% at all depths.

3.4 Air Void Content

Two concrete cores taken from the bridge deck were tested for air-void parameters in hardened concrete in accordance with ASTM C457, Microscopic Determination of Parameters of the Air-Void System in Hardened Concrete. The hardened air void analyses conducted on two cores indicated that the concrete in the deck is air entrained. Results of the air void analysis are shown in Appendix D.

3.5 Corrosion Potential

A corrosion potential survey was carried out on the bridge deck, and the two abutments to measure the potential degree of corrosion between the embedded reinforcing steel and the concrete.

The survey was undertaken in accordance with ASTMC876, Half–Cell Potentials of Uncoated Reinforcing Steel in concrete. The data collected was plotted on schematic diagrams of the bridge deck and abutments as an equipotential contour map. The plotted data are shown in Appendix E.

The corrosion potential measurements obtained from the southbound lane bridge ranged from -74 to -331 mV with an average of -171 mV. The corrosion potential measurements obtained from the northbound lane bridge ranged from -87 to -389 mV with an average value of -218 mV. According to ASTM C876, corrosion potential can be evaluated as follows:

a) if potential measurements over an area are more positive than -200mV, there is a greater than 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement
b) if potentials over an area in the range of -200 mV and -350 mV, corrosion activity of the reinforcing steel in that area is uncertain
c) if potentials over an area are more negative than -350 mV, there is a greater than 90% probability that reinforcing steel corrosion is occurring in that area at the time of measurement

Based upon our corrosion potential survey for the southbound bridge, the test data indicates a greater than 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement. A total of 978.1 m² or 74% of the deck area has corrosion potentials more positive than -200 mV. The deck area that has corrosion potentials between -200 mV and -350 mV was determined to be 349.3 m² or 26%. However, based on visual observations, isolated corrosion and delamination are present on the bottom side of the bridge.

The corrosion potential measurements for the northbound bridge indicate corrosion activity of the reinforcing steel in much of the deck area is uncertain. A total of 412 m² or 46% of the deck area has corrosion potentials more positive than -200 mV. The deck area that has corrosion potentials between -200 mV and -350 mV was determined to be 490.5 m² or 54%. A small section having an area of 2 m² area near the north end indicated a corrosion probability exceeding 90%. Based on visual observation, corrosion and delamination are present on the bottom side of the bridge.

The corrosion potential measurements obtained from the south abutment ranged from -228 mV to -324 mV with an average value of 276 mV. The abutment area that has corrosion potentials between -200 mV and -350 mV was determined to be 124 m² or 100%.

The corrosion potential measurements obtained from the north abutment ranged from -271 mV to -342 mV with an average value of 307 mV. The abutment area that has corrosion potentials between -200 mV and -350 mV was determined to be 124 m² or 100%. The test data obtained from both abutments indicates that corrosion activity of the reinforcing steel in that area is uncertain.

3.6 Miscellaneous Observations

Additional photos were taken during inspection of the substructure. The photos are shown in Appendix F.

4.0 DISCUSSION

The significant findings of our condition assessment for the Osborne Bridge are summarized below:

1. Concrete deterioration in the form of delamination was more evident in the northbound lane than the southbound lane. The distress was observed in the concrete surface exposed during removal of sawn samples. The presence of moisture underneath the asphalt pavement was not observed at any of the sample locations.
2. The asphalt pavement overlay thickness range from 52 to 91 mm with an average value of 73 mm. The depth of concrete cover over the reinforcing steel ranged from 38 to 49 mm with an average value of 44 mm.
3. The average compressive strength for the cores taken from the northbound lane deck was determined to be 40 MPa, while the average compressive strength results for the cores taken from the southbound lane deck was 63 MPa. The average compressive strength results obtained from the piers was 58 MPa.
4. The chloride content results obtained from cores taken from the deck generally had low chloride concentrations with the exception of test results obtained from slices taken at 20 to 30 mm depth. The chloride content below the 30 mm level are lower than the threshold value of 0.15% by mass of cement.
5. The chloride content obtained from all depths of the core sample taken from the south abutment seat exceeded the threshold value of 0.15% by mass of cement at all depths.
6. The hardened air void analyses conducted on two cores indicated that the concrete is suitably air entrained.

7. Based upon the corrosion potential survey data for the southbound bridge, there is a greater than 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement. However, for the northbound bridge, the corrosion potential survey indicated that in many areas, corrosion activity of the reinforcing steel in that area is uncertain, becoming more than 90% probable near the north end of the structure. Visual evidence on the lower side of the deck indicates corrosion is occurring near the underside of the bridge deck.

We appreciate the opportunity to assist you in this project. Please call if you have any questions regarding our report.

Prepared by:

Hermie Manalo
Laboratory Manager

Reviewed by:

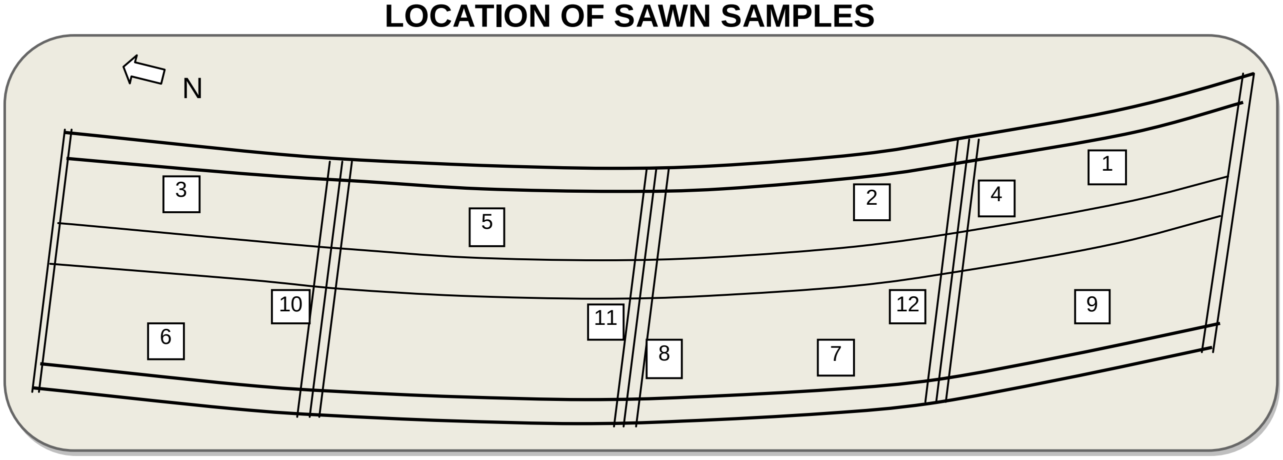
Wayne Hurley, P. Eng.
Vice-President, Engineering

APEGM
Certificate of Authorization
TBT Engineering Limited
No. 4752 Date: 03 10 22

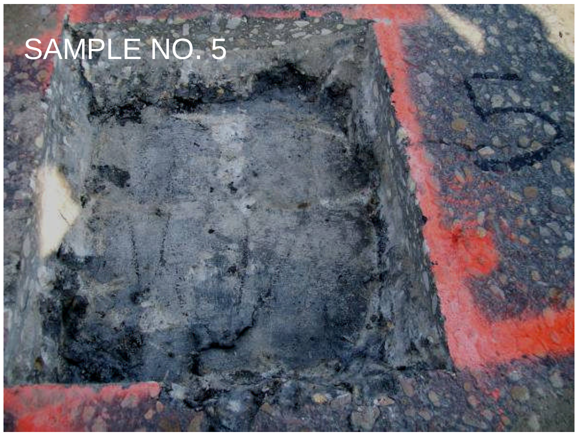
APPENDIX A
ASPHALT PAVEMENT SAWN SAMPLES:

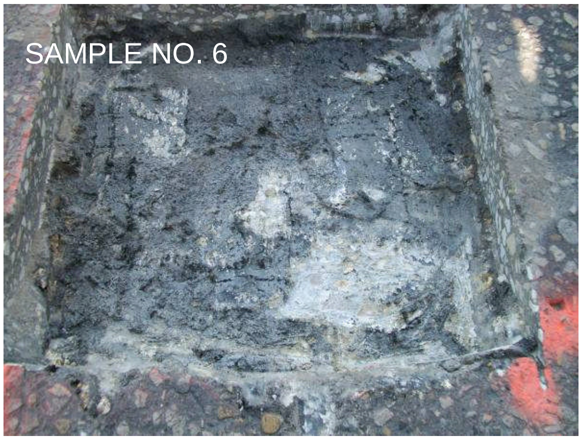
Sample No.	Sample Location	Asphalt Pavement Thickness (mm)	Concrete Cover (mm)	Remarks
1	Northbound lane, 15 m from south expansion joint	75	40	bottom surface covered with 15% substrate concrete ranging from 5 to 15 mm in depth.
2	Northbound lane, 49 m from south expansion joint	52	45	bottom surface covered with 10% substrate concrete ranging from 3 to 8 mm in depth
3	Northbound lane, 105 m from south expansion joint	68	42	bottom surface covered with 15% substrate concrete ranging from 5 to 15 mm in depth
4	Northbound lane, 30 m from south expansion joint	82	38	horizontal crack was observed in the concrete deck
5	Northbound lane, 78 m from south expansion joint	85	47	sound concrete surface
6	Southbound lane, 108 m from south expansion join	60	41	Sound concrete surface
7	Southbound lane, 46 m from south expansion joint	65	45	bottom surface covered with 20% substrate concrete ranging from 5 to 15 mm in depth
8	Southbound lane, 75 m from southbound lane	69	46	sound concrete surface
9	Southbound lane, 15 m from south expansion joint	74	49	sound concrete surface
10	Southbound lane, 98 m from south expansion joint	85	46	sound concrete surface
11	Southbound lane, 64 m from south expansion joint	91	43	sound concrete surface
12	Southbound lane, 31 m from south expansion joint	74	45	sound concrete surface, evidence of minor spalling was observed.
Average		73	44	

LOCATION OF SAWN SAMPLES



PHOTOS OF SAWN SAMPLES






SAMPLE NO. 7


SAMPLE NO. 8


SAMPLE NO. 9


SAMPLE NO. 10


SAMPLE NO. 11


SAMPLE NO. 12

APPENDIX B

CONCRETE CORES

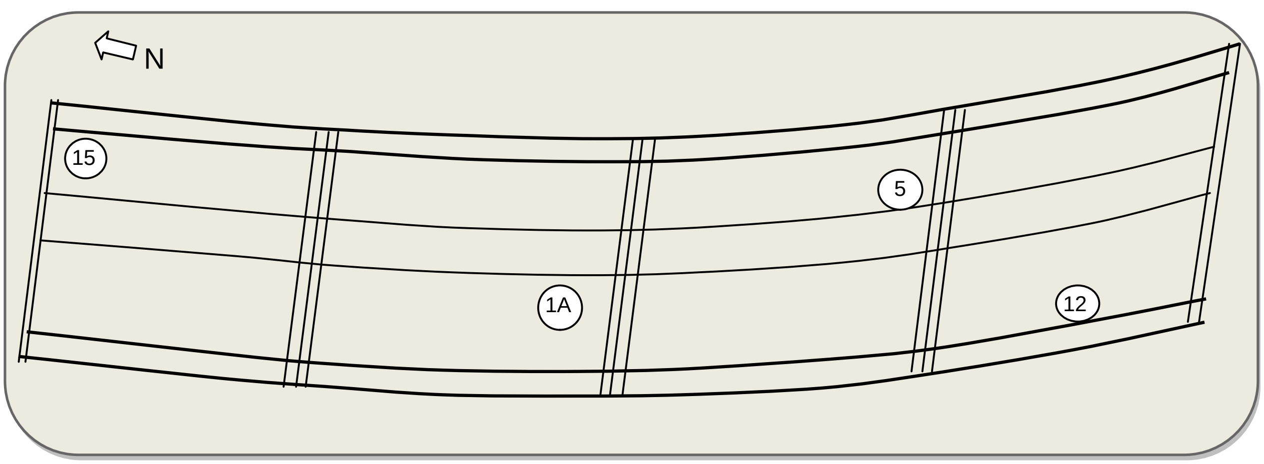
Table 1 –Bridge Deck

Core No.	Location	Thickness (mm)	Compressive Strength (MPa)
15	span 1, northbound lane	188 (full depth)	44.9
5	span 3, northbound lane	162	35.0
1A	Span 2, southbound lane	125	61.4
12	Span 4, southbound lane	125	64.7

Table 2 - Piers

Core No.	Location	Thickness (mm)	Compressive Strength (MPa)
Pier 1	North Pier, south face, 2m above waterline,	130	57.1
Pier 2	Centre Pier, north face, 2m above waterline	145	66.0
Pier 3	South Pier, north face, 2m above waterline	120	51.5

LOCATIONS OF COMPRESSIVE STRENGTH SAMPLES



PHOTOS OF BRIDGE DECK CORE SAMPLES TESTED FOR COMPRESSIVE STRENGTH

SPAN 1
Core No. 15

SPAN 2
Core No. 1A

SPAN 3
Core No. 5

SPAN 4
Core No. 12

PHOTOS OF BRIDGE PIER CORE SAMPLES TESTED FOR COMPRESSIVE STRENGTH

PIER 1

PIER 2

PIER 3

APPENDIX C

Chloride Content Test Data

Test No.	Core Location	Sample Depth (mm)	Water-Soluble Chloride Content		
			% by mass of concrete	% by mass of cement	% by mass of cement (corrected)*
1	Northbound curb lane Core #15	20-30	0.158	1.078	**1.030**
		50-60	0.025	0.171	0.123
		70-80	0.012	0.082	0.034
		90-100	0.009	0.061	0.013
		150-160	0.008	0.055	0.007
2	Northbound median lane Core #5	20-30	0.016	0.109	0.061
		50-60	0.017	0.116	0.068
		70-80	0.012	0.082	0.034
		90-100	0.016	0.109	0.061
		150-160	0.014	0.096	0.048
3	Southbound median lane Core #1A	20-30	0.044	0.300	**0.252**
		50-60	0.008	0.055	0.007
		70-80	0.010	0.068	0.020
		90-100	0.009	0.061	0.013
4	Southbound, curb lane Core #12	20-30	0.030	0.205	**0.157**
		50-60	0.009	0.061	0.013
		70-80	0.011	0.075	0.027
		90-100	0.007	0.048	0.000
5	Northbound, Median lane Core #4	20-30	0.118	0.300	**0.252**
		50-60	0.012	0.082	0.034
		70-80	0.009	0.061	0.013
		90-100	0.007	0.048	0.000
6	Southbound, curb lane Core #8	20-30	0.018	0.123	0.075
		50-60	0.013	0.089	0.041
		70-80	0.013	0.089	0.041
		90-100	0.013	0.089	0.041
7	Northbound, curb lane Core #16	20-30	0.009	0.061	0.013
		50-60	0.008	0.055	0.007
		70-80	0.007	0.048	0.000
		90-100	0.008	0.055	0.007
8	Southbound, curb lane Core #6	20-30	0.014	0.096	0.048
		50-60	0.013	0.089	0.041
		70-80	0.010	0.068	0.020
		90-100	0.013	0.089	0.048
9	Northbound, median lane Core #19	20-30	0.155	1.058	**1.010**
		50-60	0.074	0.505	**0.457**
		70-80	0.020	0.136	0.088
		90-100	0.009	0.061	0.013

Corrected for background chlorides

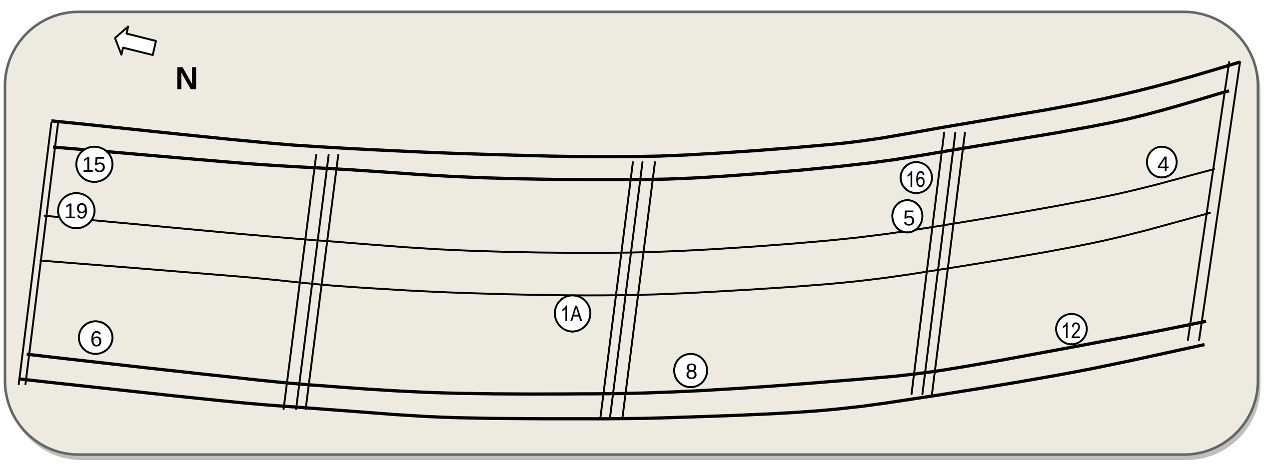
Continuation:

Test No.	Core Location	Sample Depth (mm)	Water-Soluble Chloride Content		
			% by mass of concrete	% by mass of cement	% by mass of cement (corrected)
10	South abutment seat Core #17	10-20	0.304	2.074	**2.026**
		30-40	0.212	1.447	**1.399**
		50-60	0.145	0.989	**0.941**
		90-100	0.035	0.239	**0.191**

Notes:

1. The background chloride content was determined to be 0.048% by mass of cement.
2. Test results that exceed the threshold value of 0.015% by mass of cement are highlighted in the above table.

LOCATION OF CORES TESTED FOR CHLORIDE

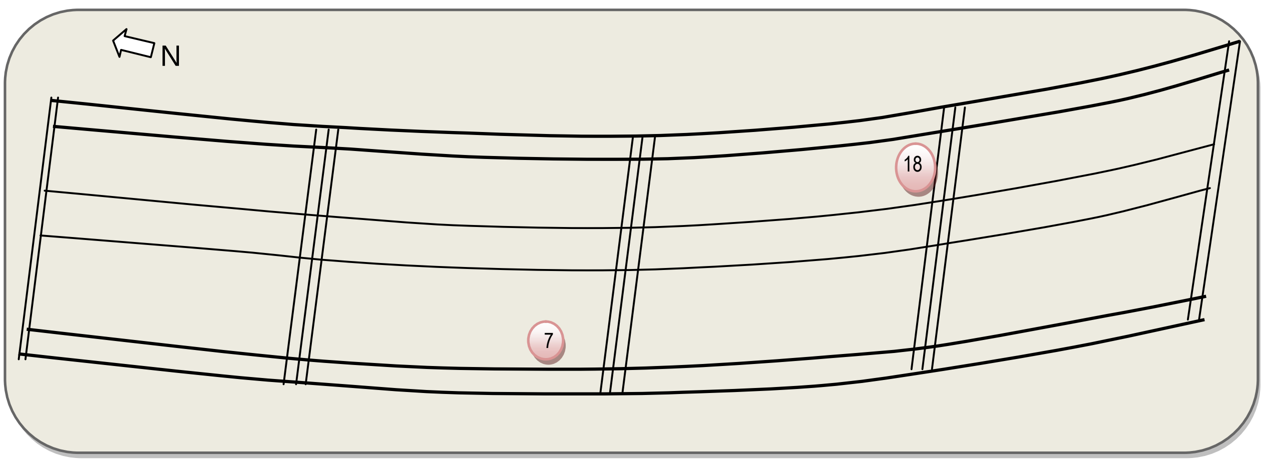


APPENDIX D

AIR VOID PARAMETERS OF HARDENED CONCRETE

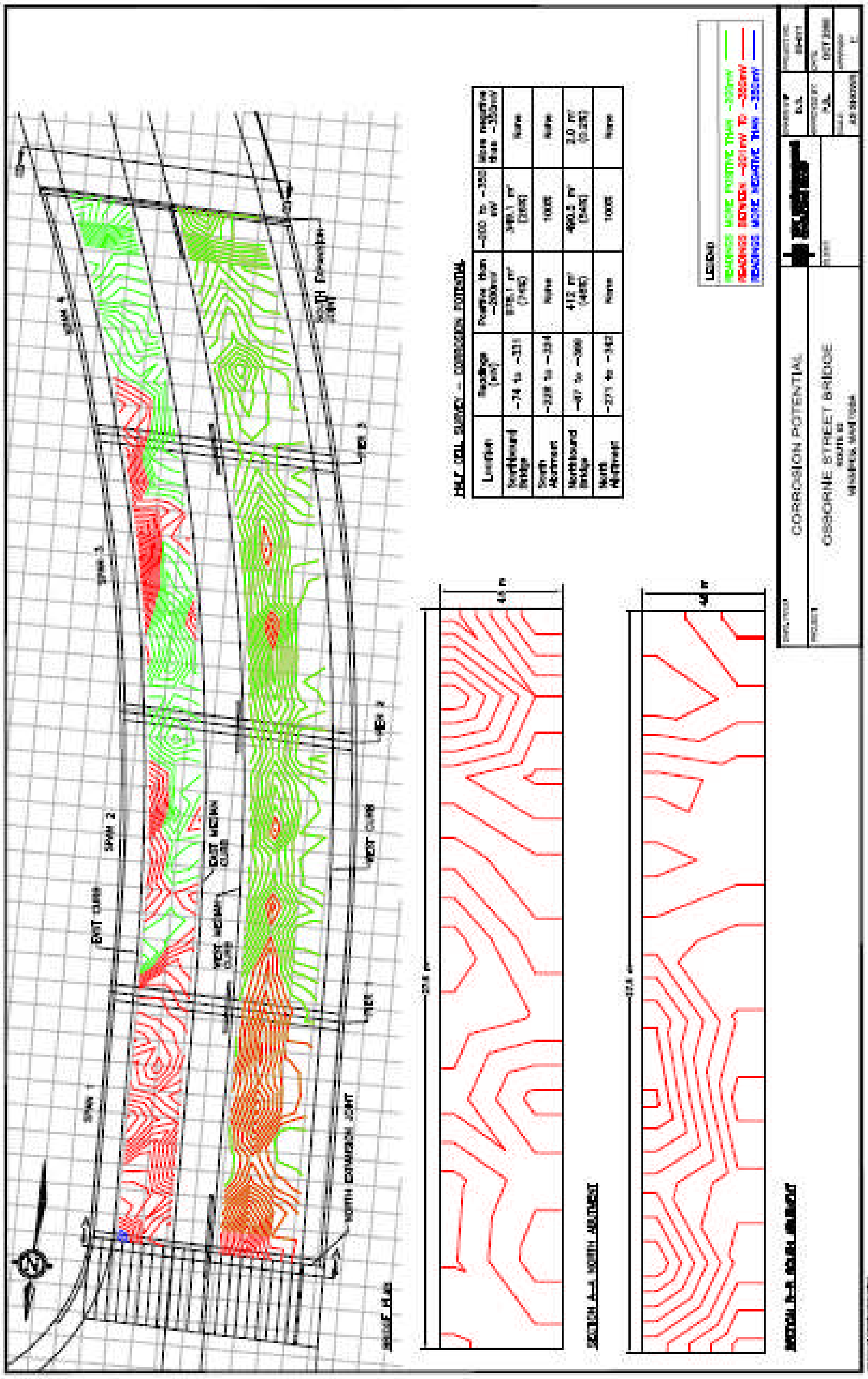
Parameters	Core No. 7	Core No. 18
total air content (%)	8.9	7.0
specific surface (mm-1)	29.14	20.26
spacing factor (mm)	0.092	0.182

LOCATION OF CORE SAMPLES TESTED FOR AIR VOID PARAMETERS



APPENDIX E

HALF CELL SURVEY - CORROSION POTENTIAL



APPENDIX F

MISCELLANEOUS PHOTOS. DECK AND SUBSTRUCTURE

CONDITION OF EXPOSED REBAR ON THE NORTHBOUND LANE

CONDITION OF EXPOSED REBAR ON THE SOUTHBOUND LANE

SOUTHBOUND BRIDGE WEST SOFFIT

NORTHBOUND BRIDGE EAST SOFFIT

EFFLORESCENCE OBSERVED ON THE UNDERSIDE
OF THE EAST SIDE OF THE NORTHBOUND BRIDGE

HEAVY CORROSION AND DELAMINATION OBSERVED ON THE WEST SIDE
OF THE NORTHBOUND BRIDGE

ISOLATED CORROSION AND DELAMINATION OBSERVED ON THE EAST SIDE OF THE SOUTHBOUND BRIDGE

CONDITION OF THE SOUTH ABUTMENT SEAT

CONDITION OF THE BRIDGE BEARING ON THE NORTH ABUTMENT

EVIDENCE OF PREVIOUS FULL DEPTH REPAIR