

APPENDIX A

*CONDITION SURVEY OF FORT
GARRY BRIDGE DECKS BY
NATIONAL TESTING
LABORATORIES LTD.*

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Project: Fort Garry Twin Bridges

Attention: Vaibhav Banthia

A coring program for the Fort Garry Twin Bridges was undertaken from May 14 to 23, 2007. Core samples were obtained from the bridge deck and piers at locations identified on site by Wardrop personnel. The thickness of the asphalt overlay was recorded at each core location on the bridge deck. Where reinforcing steel was exposed at core locations in the bridge deck, the concrete cover over the reinforcing steel was measured. The concrete cover is shown in Tables 1 and 2. The core samples were returned to our laboratory and the following tests were conducted:

- water-soluble chloride content (CSA A23.2-4B)
- core compressive strength (CSA A23.2-14C)
- rapid chloride permeability (ASTM C1202)

Asphalt Pavement Thickness

The asphalt pavement thickness for core samples from the bridge deck was determined in accordance with ASTM D3549, Thickness or Height of Compacted Bituminous Paving Mixture Specimens. The thickness of the asphalt pavement on the bridge deck ranged from 33 to 90 mm, with an average thickness of 62 mm. The asphalt pavement thicknesses recorded at the core locations on the bridge deck is shown in Tables 1 and 2.

Water-Soluble Chloride Content

Slices were typically cut from the core samples and tested at the following depths below the surface of the concrete slab for the bridge deck:

- 25 to 50 mm
- 75 to 100 mm
- 125 to 150 mm

For the piers, chloride contents were determined at the following depths below the surface of the concrete pier:

- 0 to 25 mm
- 75 to 100 mm
- 125 to 150 mm

At some core locations on the bridge deck, chloride contents were only conducted at the first two depths because reinforcing steel was encountered at a shallow depth at the core location. Chloride contents were also determined on a limited number of slices from a depth of 175 to 200 mm to establish the background chloride content of the concrete. Testing was performed in accordance with CSA A23.2-4B, Sampling and Determination of Water-Soluble Chloride Ion Content In Hardened Grout or Concrete.

Densities of the core samples were determined to allow calculation of chloride content, percent by mass of cement. The chloride content, percent by mass of cement, is based upon the concrete density obtained from the cores and an estimated cement content. The chloride content results are shown in Tables 1 to 4.

The chloride content value necessary to depassivate embedded steel and permit corrosion in the presence of oxygen and moisture is typically taken to be 0.15% by mass of cement. In order to determine whether sufficient chloride has entered the concrete to cause corrosion of the reinforcement, it is necessary to correct the test results for the background chloride content which is measured by the test method but does not contribute to corrosion. This is done by subtracting the chloride content measured in slices most remote from the surface of the concrete from the remaining test values and then comparing the results with the threshold value of 0.15% by mass of cement. Based upon the test results for the bridge deck core samples, a value of 0.04% was used to correct the measured values for chloride content. For core samples recovered from the bridge piers, a value of 0.03% was used to correct the measured values for chloride content. A summary of the chloride contents corrected for background chlorides is provided below.

Core Location	Average Water-Soluble Chloride Content (% by mass of cement)		
	25 to 50 mm	75 to 100 mm	125 to 150 mm
bridge deck - north structure	0.07	0.04	0.01
bridge deck - south structure	0.23	0.09	0.05
piers - north structure	0.18	0.01	0.01
piers - south structure	0.10	<0.01	<0.01

Compressive Strength

Core samples recovered from the bridges were tested in accordance with CSA A23.2-14C, Obtaining and Testing Drilled Cores for Compressive Strength. The core samples were submerged in water at room temperature for 40 hours prior to the compression test. The compressive strength results are shown in Tables 1 to 4. A summary of the compressive strength results is provided in the following table.

Core Location	Compressive Strength (MPa)	
	Range	Average
bridge deck - north structure	34.5 to 45.9	41.3
bridge deck - south structure	25.0 to 61.8	42.8
piers - north structure	48.2 to 54.0	52.5
piers - south structure	44.3 to 55.5	49.4

Rapid Chloride Permeability

Four core samples recovered from the bridge decks were tested in accordance with ASTM C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. The test results are shown in Table 5. Based upon the test results obtained for the core samples, the chloride ion penetrability of the bridge deck is considered to be low (1000 to 2000 coulombs). One core sample from the bridge deck for the north structure has a chloride ion penetrability considered to be very low (<1000 coulombs).

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



Don Flatt, M.Eng., P.Eng.
Senior Materials Engineer

TABLE 1
FORT GARRY TWIN BRIDGES - NORTH BRIDGE DECK
CHLORIDE CONTENT AND COMPRESSIVE STRENGTH TEST DATA

Core ID	Compressive Strength (MPa)	Asphalt Pavement Thickness (mm)	Concrete Cover (mm)	Sample Depth (mm)	Water-Soluble Chloride Content		Water-Soluble Chloride Content Corrected for Background Chlorides
					(% by mass of concrete)	(% by mass of cement)	(% by mass of cement)
NBEASa		108	65	25 to 50	0.037	0.26	0.22
				75 to 100	0.024	0.17	0.13
NBEASb	41.2	104	72	25 to 50	0.046	0.32	0.28
				75 to 100	0.042	0.30	0.26
NBEAa		60	92	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
NBEAb	47.4	46	80	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
NBEAc		14	85	25 to 50	0.130	0.92	0.88
				75 to 100	0.030	0.21	0.17
				125 to 150	0.006	0.04	0.00
NBS5a	34.5	50	50	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
NBS5b		40	65	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
NBS5c	38.0	52	60	25 to 50	0.007	0.05	0.01
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
				175 to 200	0.018	0.13	0.09
NBS4a		47	72	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
NBS4b	44.9	41	75	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
NBS4c		48	63	25 to 50	0.012	0.08	0.04
				75 to 100	0.009	0.06	0.02
				125 to 150	0.007	0.05	0.01
NBP3a		37	154	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
NBP3b		41	165	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	0.006	0.04	0.00
NBS3a	39.7	33	48	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.006	0.04	0.00
				125 to 150	0.028	0.20	0.16
NBS3b		38		25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
				175 to 200	0.005	0.04	0.00
NBS3c	38.6	56	91	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.007	0.05	0.01
				125 to 150	<0.005	<0.04	0.00
NBP2a		40	92	25 to 50	0.007	0.05	0.01
				75 to 100	0.006	0.04	0.00
				125 to 150	0.008	0.06	0.02
NBP2b		40	73	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.008	0.06	0.02
				125 to 150	<0.005	<0.04	0.00
				175 to 200	<0.005	<0.04	0.00

TABLE 1
FORT GARRY TWIN BRIDGES - NORTH BRIDGE DECK
CHLORIDE CONTENT AND COMPRESSIVE STRENGTH TEST DATA

Core ID	Compressive Strength (MPa)	Asphalt Pavement Thickness (mm)	Concrete Cover (mm)	Sample Depth (mm)	Water-Soluble Chloride Content		Water-Soluble Chloride Content Corrected for Background Chlorides
					(% by mass of concrete)	(% by mass of cement)	(% by mass of cement)
NBS2a	 	48	70	25 to 50	0.005	0.04	0.00
				75 to 100	0.009	0.06	0.02
				125 to 150	0.007	0.05	0.01
NBS2b	39.5	47	65	25 to 50	0.008	0.06	0.02
				75 to 100	0.007	0.05	0.01
				125 to 150	0.007	0.05	0.01
NBS2c	 	38	140	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.008	0.06	0.02
				125 to 150	<0.005	<0.04	0.00
NBS1a	38.2	61	50	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.007	0.05	0.01
				125 to 150	0.006	0.04	0.00
NBS1b	 	44	 	25 to 50	0.009	0.06	0.02
				75 to 100	0.007	0.05	0.01
				125 to 150	0.006	0.04	0.00
NBS1c	46.1	40	98	25 to 50	0.006	0.04	0.00
				75 to 100	0.006	0.04	0.00
				125 to 150	0.013	0.09	0.05
NBWaa	 	40	76	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
NBWAb	45.9	50	127	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
NBWAc	 	50	82	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.008	0.06	0.02
				125 to 150	<0.005	<0.04	0.00
NBWASa	 	90	64	25 to 50	0.072	0.51	0.47
				75 to 100	0.025	0.18	0.14
NBWASb	41.8	113	 	25 to 50	0.007	0.05	0.01
				75 to 100	0.049	0.35	0.31



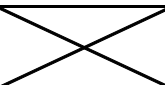


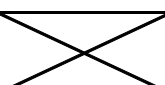




Notes

1. The water-soluble chloride content was determined in accordance with CSA A23.2-4B.
2. The reported detection limit for water-soluble chloride content is 0.005% by mass of concrete.
3. The background chloride content was determined to be 0.04% by mass of cement.
4. Test results that exceed the threshold value of 0.15% by mass of cement are highlighted in the above table.
5. The chloride content, % by mass of cement, is based upon a concrete density of 2260 kg/m³ and an estimated cement content of 320 kg/m³.

TABLE 2
FORT GARRY TWIN BRIDGES - SOUTH BRIDGE DECK
CHLORIDE CONTENT AND COMPRESSIVE STRENGTH TEST DATA

Core ID	Compressive Strength (MPa)	Asphalt Pavement Thickness (mm)	Concrete Cover (mm)	Sample Depth (mm)	Water-Soluble Chloride Content		Water-Soluble Chloride Content Corrected for Background Chlorides
					(% by mass of concrete)	(% by mass of cement)	(% by mass of cement)
SBWESc		85		25 to 50	0.115	0.81	0.77
				75 to 100	0.046	0.32	0.28
				125 to 150	0.022	0.16	0.12
SBEASb	35.2	80		25 to 50	0.076	0.54	0.50
				75 to 100	0.034	0.24	0.20
				125 to 150	0.022	0.16	0.12
SBEAa		40	70	25 to 50	0.086	0.61	0.57
				75 to 100	0.006	0.04	0.00
				125 to 150	0.018	0.13	0.09
SBEAb	61.8	72		25 to 50	0.094	0.66	0.62
				75 to 100	0.018	0.13	0.09
				125 to 150	<0.005	<0.04	0.00
SBEAc		67	80	25 to 50	0.018	0.13	0.09
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS5a	25.0	54	60	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.007	0.05	0.01
				125 to 150	<0.005	<0.04	0.00
SBS5b		70		25 to 50	0.134	0.95	0.91
				75 to 100	0.014	0.10	0.06
				125 to 150	<0.005	<0.04	0.00
SBS5c	43.1	53		25 to 50	0.006	0.04	0.00
				75 to 100	0.006	0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS4a		50	161	25 to 50	0.008	0.06	0.02
				75 to 100	0.005	0.04	0.00
				125 to 150	<0.005	<0.04	0.00
				175 to 200	<0.005	<0.04	0.00
SBS4b	43.0	55	90	25 to 50	0.008	0.06	0.02
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS4c		63	70	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.006	0.04	0.00
				125 to 150	0.008	0.06	0.02
SBP3a		52		25 to 50	0.007	0.05	0.01
				75 to 100	0.006	0.04	0.00
				125 to 150	<0.005	<0.04	0.00
				175 to 200	0.008	0.06	0.02
SBP3b		50	94	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS3a	44.1	48	64	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
				175 to 200	<0.005	<0.04	0.00
SBS3b		63	65	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS3c	36.7	72	78	25 to 50	0.006	0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBP2a		48	68	25 to 50	0.168	1.19	1.15
				75 to 100	0.006	0.04	0.00
				125 to 150	0.005	0.04	0.00
				175 to 200	<0.005	<0.04	0.00
SBP2b		54		25 to 50	<0.005	<0.04	0.00
				75 to 100	0.005	0.04	0.00
				125 to 150	<0.005	<0.04	0.00

TABLE 2
FORT GARRY TWIN BRIDGES - SOUTH BRIDGE DECK
CHLORIDE CONTENT AND COMPRESSIVE STRENGTH TEST DATA

Core ID	Compressive Strength (MPa)	Asphalt Pavement Thickness (mm)	Concrete Cover (mm)	Sample Depth (mm)	Water-Soluble Chloride Content		Water-Soluble Chloride Content Corrected for Background Chlorides
					(% by mass of concrete)	(% by mass of cement)	(% by mass of cement)
SBS2a		60	68	25 to 50	0.249	1.76	1.72
				75 to 100	0.255	1.80	1.76
				125 to 150	0.168	1.19	1.15
SBS2b	41.4	50	85	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS2c		52	70	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.005	0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS1a	39.9	60	65	25 to 50	<0.005	<0.04	0.00
				75 to 100	0.006	0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBS1b		47	83	25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	0.005	0.04	0.00
SBS1c	45.1	52	63	25 to 50	0.005	0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBWAa		70		25 to 50	0.009	0.06	0.02
				75 to 100	0.036	0.25	0.21
				125 to 150	0.005	0.04	0.00
SBWAb	55.4	50	85	25 to 50	0.006	0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBWAc		60		25 to 50	<0.005	<0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	<0.005	<0.04	0.00
SBWASb	43.2	75		25 to 50	0.006	0.04	0.00
				75 to 100	<0.005	<0.04	0.00
				125 to 150	0.006	0.04	0.00
SBWASc		80		25 to 50	0.038	0.27	0.23
				75 to 100	0.018	0.13	0.09
				125 to 150	0.008	0.06	0.02

Notes

1. The water-soluble chloride content was determined in accordance with CSA A23.2-4B.
2. The reported detection limit for water-soluble chloride content is 0.005% by mass of concrete.
3. The background chloride content was determined to be 0.04% by mass of cement.
4. Test results that exceed the threshold value of 0.15% by mass of cement are highlighted in the above table.
5. The chloride content, % by mass of cement, is based upon a concrete density of 2260 kg/m³ and an estimated cement content of 320 kg/m³.

**TABLE 3
FORT GARRY TWIN BRIDGES - NORTH BRIDGE PIERS
CHLORIDE CONTENT AND COMPRESSIVE STRENGTH TEST DATA**

Core Location	Compressive Strength (MPa)	Sample Depth (mm)	Water-Soluble Chloride Content		Water-Soluble Chloride Content Corrected for Background Chlorides
			(% by mass of concrete)	(% by mass of cement)	(% by mass of cement)
Pier 1 north face 0.5 m below top of pier 0.6 m from west side of pier	53.5	0 to 25	0.009	0.06	0.03
		75 to 100	0.005	0.03	0.00
		125 to 150	<0.005	<0.03	0.00
Pier 2 south face 0.2 m below top of pier 0.4 m from east side of pier	52.6	0 to 25	0.076	0.52	0.49
		75 to 100	<0.005	<0.03	0.00
		125 to 150	<0.005	<0.03	0.00
Pier 2 north face 0.6 m below top of pier 0.5 m from west side of pier	54.0	0 to 25	0.041	0.28	0.25
		75 to 100	0.005	0.03	0.00
		125 to 150	0.005	0.03	0.00
Pier 3 south face 0.3 m below top of pier 0.6 m from east side of pier	52.8	0 to 25	0.044	0.30	0.27
		75 to 100	0.007	0.05	0.02
		125 to 150	0.007	0.05	0.02
Pier 3 north face 0.3 m below top of pier 0.7 m from east side of pier	54.0	0 to 25	0.012	0.08	0.05
		75 to 100	0.007	0.05	0.02
		125 to 150	0.006	0.04	0.01
Pier 4 north face 0.5 m below top of pier 0.9 m from east side of pier	48.2	0 to 25	0.007	0.05	0.02
		75 to 100	<0.005	<0.03	0.00
		125 to 150	<0.005	<0.03	0.00

Notes

1. The water-soluble chloride content was determined in accordance with CSA A23.2-4B.
2. The reported detection limit for water-soluble chloride content is 0.005% by mass of concrete.
3. The background chloride content was determined to be 0.03% by mass of cement.
4. Test results that exceed the threshold value of 0.15% by mass of cement are highlighted in the above table.
5. The chloride content, % by mass of cement, is based upon a concrete density of 2310 kg/m³ and an estimated cement content of 340 kg/m³.

**TABLE 4
FORT GARRY TWIN BRIDGES - SOUTH BRIDGE PIERS
CHLORIDE CONTENT AND COMPRESSIVE STRENGTH TEST DATA**

Core Location	Compressive Strength (MPa)	Sample Depth (mm)	Water-Soluble Chloride Content		Water-Soluble Chloride Content Corrected for Background Chlorides
			(% by mass of concrete)	(% by mass of cement)	(% by mass of cement)
Pier 1 south face 0.4 m below top of pier 0.6 m from east side of pier	55.5	0 to 25	0.006	0.04	0.01
		75 to 100	<0.005	<0.03	0.00
		125 to 150	0.008	0.05	0.02
Pier 2 south face 0.6 m below top of pier 0.6 m from east side of pier	48.7	0 to 25	0.015	0.10	0.07
		75 to 100	<0.005	<0.03	0.00
		125 to 150	<0.005	<0.03	0.00
Pier 2 north face 0.3 m below top of pier 0.4 m from west side of pier	48.0	0 to 25	0.036	0.24	0.21
		75 to 100	<0.005	<0.03	0.00
		125 to 150	<0.005	<0.03	0.00
Pier 3 south face 0.7 m below top of pier 0.4 m from east side of pier	44.3	0 to 25	0.011	0.07	0.04
		75 to 100	0.006	0.04	0.01
		125 to 150	<0.005	<0.03	0.00
Pier 3 north face 0.2 m below top of pier 0.5 m from west side of pier	53.8	0 to 25	0.044	0.30	0.27
		75 to 100	<0.005	<0.03	0.00
		125 to 150	<0.005	<0.03	0.00
Pier 4 south face 0.6 m below top of pier 0.6 m from east side of pier	45.9	0 to 25	0.007	0.05	0.02
		75 to 100	0.006	0.04	0.01
		125 to 150	<0.005	<0.03	0.00

Notes

1. The water-soluble chloride content was determined in accordance with CSA A23.2-4B.
2. The reported detection limit for water-soluble chloride content is 0.005% by mass of concrete.
3. The background chloride content was determined to be 0.03% by mass of cement.
4. Test results that exceed the threshold value of 0.15% by mass of cement are highlighted in the above table.
5. The chloride content, % by mass of cement, is based upon a concrete density of 2310 kg/m³ and an estimated cement content of 340 kg/m³.

TABLE 5
FORT GARRY TWIN BRIDGES
CHLORIDE ION PENETRABILITY TEST DATA

Core ID	Core Location	Charge Passed in 6 Hours (coulombs)
NBEAb	east end of north bridge	723
NBS3a	centre of north bridge	1308
SBEAc	east end of south bridge	1234
SBS3c	centre of south bridge	1387