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16. Abstract

Cores were removed from segments as part of the fifth engineering inspection of the I-75 Zilwaukee Bridge, which started in September 2005. Coring was done to perform an invasive post-tensioning inspection. This was the first time cores had been removed from segments and provided the opportunity to determine chloride contents of the concrete segments.

The average water soluble chloride content just below the latex concrete wearing surface is 0.25 lb/yd^3, while the average chloride content about 7 in. below the bottom of the latex concrete wearing surface is around 0.15 lb/yd^3. If the chloride content at 7 in. below the bottom of the latex concrete surface is considered background chloride, then there is an apparent ingress of chloride into the segment concrete through the latex concrete wearing surface. While the chloride content is well below the corrosion threshold of 1.2 lb/yd^3, it is troublesome. The source of the chloride is not clear since the cores were taken well within the ends of the bridge and deicing salts are not used on the bridge.

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MICHIGAN DEPARTMENT OF TRANSPORTATION
MDOT

Chloride Content In Segments Of The Zilwaukee Bridge

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Structural Section
Construction and Technology Division
Research Report R-1491

Lansing, Michigan
May 2007

INTRODUCTION

Cores were removed from segments as part of the fifth engineering inspection of the I-75 Zilwaukee Bridge, which started in September 2005. Coring was done to perform an invasive post-tensioning inspection. Details of the coring can be found in the 2005 Bridge Inspection Report, Zilwaukee Bridge by Parsons Transportation Group. This was the first time cores had been removed from segments and provided the opportunity to determine chloride contents of the concrete segments. Previously, only chloride content of the latex overlay had been determined.

PROCEDURE

Thirty six, 2-in. diameter cores from the top flange of segments were taken to allow inspection of cantilever tendons over pier 14 in northbound spans 14 and 15. Core pieces were retrieved from the Zilwaukee Bridge maintenance office in June 2006, assembled to recreate the complete full length of the core and photographed. Eleven cores from the 36 cores taken from the top flange of segments were selected for chloride testing.

A ½-in. slice was cut from each core just below the latex concrete overlay and near the end of the core. Details of the cores and slice locations are shown in Table 1. Portions of the ½-in. slice were ground and water soluble chloride content was determined according to ASTM C 1218, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete. The epoxy bond line material in the core slice was excluded from the sample for chloride testing.

TABLE 1
Selected Zilwaukee Bridge Cores
Northbound Spans 14 and 15

Core Location ID	Core Length (in.)	Depth of Latex Concrete (in.)	Depth to top of Bottom Slice (in.)
W 6N T2	6.875	2.25	6.25
W 1N T16	8.625	2.50	7.875
W 11N T2	7.375	2.00	6.75
W 14N T3	7.375	1.50	7.00
W 11S T16	7.25	2.25	6.875
E 14N T2	7.875	2.25	7.375
E 11S T16	8.00	2.25	7.375
E 6S T3	6.125	2.125	5.50
E 1N T2	8.625	3.25	8.00
E 6N T2	7.875	2.625	7.25
E 11N T3	8.50	2.75	8.00

Core Location ID indicates east/west side of bridge, bulkhead designation, and tendon number according to 2005 Bridge Inspection Report, Zilwaukee Bridge by Parsons Transportation Group.

Subsequent to the initial chloride testing, a thin slice of the core from location E 6S T3 was cut from close to the original bottom sample location. The coarse aggregate was separated from the thin slice using maleic acid. Water soluble chloride content of the coarse aggregate and the composite concrete slice was determined according to ASTM C 1218.

FINDINGS

Nothing unusual was observed in the cores. Water soluble chloride content from the cores is shown in Table 2. The threshold for water soluble chloride detection is 0.1 lb/yd^3. There were three samples that were below the detection threshold and are noted as None Detected (N.D.) in Table 2.

TABLE 2
Water Soluble Chloride Content

Sample No.	Sample ID	Water soluble chloride content (lb/yd^3)	Sample No.	Sample ID	Water soluble chloride content (lb/yd^3)
1	W 14N T3 Top	0.25	13	E 1N T2 Bottom	#0.15 (0.17)
2	W 14N T3 Top (duplicate)	0.25	14	E 6N T2 Top	#0.51 (0.81)
3	W 14N T3 Bottom	0.17	15	E 6N T2 Bottom	N.D.
4	W 1N T16 Bottom	0.15	16	E 6S T3 Top	0.25
5	W 1N T16 Top	0.20	17	E 6S T3 Bottom	0.20
6	W 11N T2 Top	0.25	18	E 14N T2 Top	0.22
7	W 11N T2 Bottom	0.17	19	E 14N T2 Bottom	0.22
8	W 11S T16 Top	0.26	20	E 11N T3 Top	0.24
9	W 11S T16 Bottom	#0.30 (0.37)	21	E 11N T3 Bottom	N.D.
10	W 6N T2 Top	0.24	22	E 11S T16 Top	#0.16 (0.17)
11	W 6N T2 Bottom	N.D.	23	E 11S T16 Bottom	0.23
12	E 1N T2 Top	0.15	24	Analysis Blank	N.D.

Sample ID indicates east/west side of bridge, bulkhead designation, tendon number (according to 2005 Bridge Inspection Report, Zilwaukee Bridge by Parsons Transportation Group) and top/bottom of core.

N.D. indicates none detected. # indicates lowest value of two tests.

Chloride content sample results were paired (top and bottom) according to location and are shown in Table 3.

TABLE 3 Water Soluble Chloride Content			
	Water soluble chloride content (lb/yd^3)		
Sample ID	Top	Bottom	
W 14N T3	0.25	0.17	
W 11N T2	0.25	0.17	
W 6N T2	0.24	N.D.	
W 1N T16	0.20	0.15	
W 11S T16	0.26	#0.30 (0.37)	
E 11S T16	0.17	#0.16 (0.23)	
E 6S T3	0.25	0.20	
E 1N T2	0.15	#0.15 (0.17)	
E 6N T2	#0.51 (0.81)	N.D.	
E 11N T3	0.24	N.D.	
E 14N T2	0.22	0.22	
Average	0.25	0.14*	0.16**
Standard deviation	0.09	0.09*	0.06**

Sample ID indicates east/west side of bridge, bulkhead designation, and tendon number according to 2005 Bridge Inspection Report, Zilwaukee Bridge by Parsons Transportation Group.

N.D. indicates none detected. # indicates lowest value used in average and standard deviation calculation. *Calculated with N.D. equal to 0.01. **Calculated with N.D. equal to 0.09.

Chloride content of the east and west side of the bridge just below the latex concrete overlay and near the bottom of the core is shown in Figures 1 and 2.

Figure 1. Water Soluble Chloride Content of the West Side Zilwaukee Bridge Cores

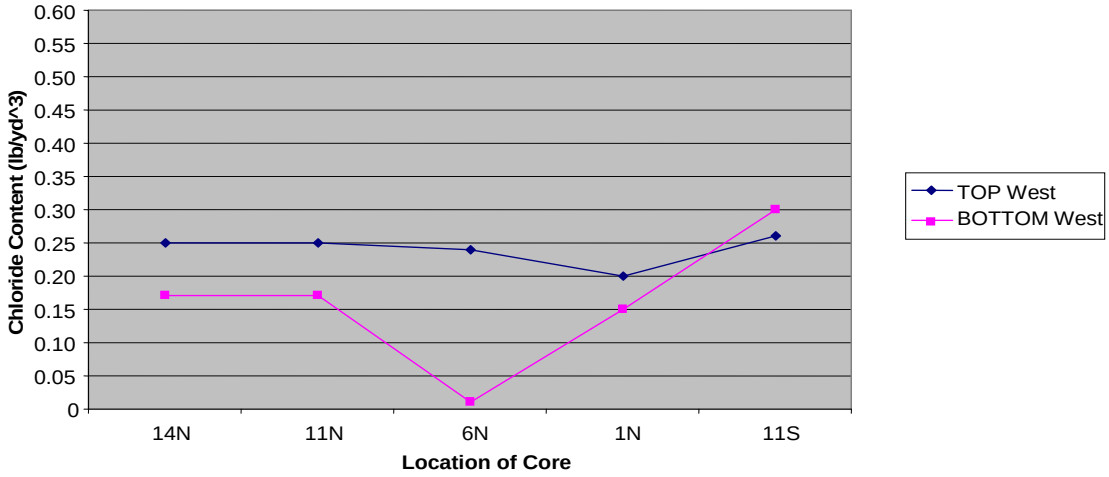
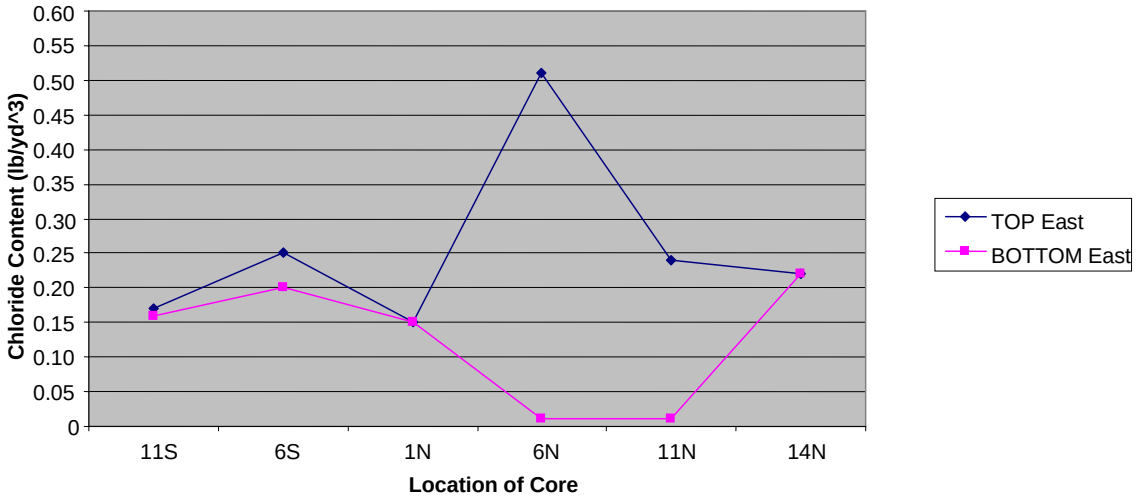


Figure 2. Water Soluble Chloride Content of the East Side Zilwaukee Bridge Cores



Chloride content of the coarse aggregate and the composite concrete slice taken from close to the original bottom sample location E 6S T3 is shown in Table 4.

TABLE 4
Water Soluble Chloride Content

Sample ID	Water soluble chloride content (lb/yd^3)
E 6S T3 Coarse aggregate	0.11
E 6S T3 Composite concrete	0.18

Sample ID indicates east/west side of bridge, bulkhead designation, and tendon number according to 2005 Bridge Inspection Report, Zilwaukee Bridge by Parsons Transportation Group.

The laboratory test reports are included in Appendix A.

DISCUSSION

It should be noted that the chloride content near the bottom of the core is higher than just below the latex concrete overlay at one location (highlighted in Table 3). This is contrary to what would be expected. According to ASTM C 1218, results of two properly conducted tests in the same laboratory on the same material are not expected to differ by more than 0.0037%. This minor variation in test results would not account for the bottom chloride content being higher than the top. Remaining pieces of the three cores were inspected for signs of cracking, which might explain the higher chloride content near the bottom of the core, to no avail. One possible explanation is variation of the chloride content within the sample, but this has not been confirmed.

A T-test was done on the difference between the means (unmatched groups) of the top chloride content and the chloride content near the bottom of the core. Assuming a maximum chloride content of 0.01 lb/yd^3 or 0.09 lb/yd^3 for the "None Detected" test results and using a two tail test, the difference between the group means was statistically significant at the 0.05 level.

There appears to be soluble chloride in the coarse aggregate based on the testing done on slices taken from near the bottom of the core from location E 6S T3. The chloride content (0.18 lb/yd^3) of the composite concrete sample from the slice matches reasonable well with that of the chloride content (0.20 lb/yd^3) of the original bottom sample at that location.

The average water soluble chloride content just below the latex concrete wearing surface is 0.25 lb/yd^3, while the average chloride content about 7" below the bottom of the latex concrete wearing surface is around 0.15 lb/yd^3. If the chloride content at 7" below the bottom of the latex concrete surface is considered background chloride, then there is an apparent ingress of chloride into the segment concrete through the latex concrete wearing surface. While the chloride content is well below the corrosion threshold of 1.2 lb/yd^3, it is troublesome. The source of the chloride is not clear since the cores were taken well within the ends of the bridge and deicing salts are not used on the bridge.

RECOMMENDATIONS

Slush samples should be taken after the bridge has been treated for snow removal during the winter months. Chloride content of these samples should be determined in an effort to ensure that deicing salts are not being tracked on the bridge from normal traffic.

Future cores of segments should be tested for chloride content to corroborate the results reported here.

APPENDIX A

Laboratory Test Reports

MDOT
Michigan Department of Transportation

Testing and Research Section
Secondary Governmental Complex
P.O. Box 30049
Lansing, Michigan 48909

Job Number	85507A
Tested Stock	N
Control Section Identity	73112 B03
Laboratory No.	N/A
Date	August 14, 2006

REPORT OF TEST

Report on sample of CONCRETE CORES	
Date sampled October 10, 22, and 24, 2005	Date received unknown
Source of material Zilwaukee bridge tendon duct locations	
Sampled from structure	Quantity represented n/a
Submitted by R. Till	Lot # n/a
Intended use water soluble chloride analysis	Specification n/a

Test Results

No.	Sample ID	Water soluble chloride content (lb/yd^3)	No.	Sample ID	Water soluble chloride content (lb/yd^3)
1	W 14N T3 TOP	0.25	13	E 1N T2 BOTTOM	0.17
2	W 14N T3 TOP (duplicate)	0.25	14	E 6N T2 TOP	0.51
3	W 14N T3 BOTTOM	0.17	15	E 6N T2 BOTTOM	N.D.
4	W 1N T16 BOTTOM	0.15	16	E 6S T3 TOP	0.25
5	W 1N T16 TOP	0.20	17	E 6S T3 BOTTOM	0.20
6	W 11N T2 TOP	0.25	18	E 14N T2 TOP	0.22
7	W 11N T2 BOTTOM	0.17	19	E 14N T2 BOTTOM	0.22
8	W 11S T16 TOP	0.26	20	E 11N T3 TOP	0.24
9	W 11S T16 BOTTOM	0.37	21	E 11N T3 BOTTOM	N.D.
10	W 6N T2 TOP	0.24	22	E 11S T16 TOP	0.17
11	W 6N T2 BOTTOM	N.D.	23	E 11S T16 BOTTOM	0.23
12	E 1N T2 TOP	0.15	24	ANALYSIS BLANK	N.D.

REMARKS: Tested for information. Corrosion threshold for uncoated reinforcement is 1.2 lb/yd^3.
Tested in accordance with ASTM C1218. N.D. = not detected, below the method detection limit of 0.1 lb/yd^3.

cc: S. Kahl

Signed _____
Supervising Engineer, Experimental Studies

MDOT
Michigan Department of Transportation

Testing and Research Section
Secondary Governmental Complex
P.O. Box 30049
Lansing, Michigan 48909

Job Number	85507A
Tested Stock	N
Control Section Identity	73112 B03
Laboratory No.	supplemental report
Date	October 12, 2006

REPORT OF TEST

Report on sample of CONCRETE CORES	
Date sampled October 10, 22, and 24, 2005	Date received unknown
Source of material Zilwaukee bridge tendon duct locations	
Sampled from structure	Quantity represented n/a
Submitted by R. Till	Lot # n/a
Intended use water soluble chloride analysis	Specification n/a

Test Results

No.	Sample ID	Water soluble chloride content (lb/yd^3)
1	E 1N T2 BOTTOM	0.15
2	E 6N T2 TOP	0.81
3	E 11S T16 BOTTOM	0.16
4	W 11S T16 BOTTOM	0.30

REMARKS: Tested for information. Corrosion threshold for uncoated reinforcement is 1.2 lb/yd^3.
Tested in accordance with ASTM C1218.

cc: S. Kahl

Signed _____
Supervising Engineer, Experimental Studies

MDOT
Michigan Department of Transportation

Testing and Research Section
Secondary Governmental Complex
P.O. Box 30049
Lansing, Michigan 48909

Job Number	85507A
Tested Stock	N
Control Section Identity	73112 B03
Laboratory No.	N/A
Date	January 17, 2007

REPORT OF TEST

Report on sample of CONCRETE CORES	
Date sampled October 10, 22, and 24, 2005	Date received unknown
Source of material Zilwaukee bridge tendon duct locations	
Sampled from structure	Quantity represented n/a
Submitted by R. Till	Lot # n/a
Intended use water soluble chloride analysis	Specification n/a

Test Results

No.	Sample ID	Water soluble chloride content (lb/yd^3)
1	E 6S T3 BOTTOM (AGGREGATE PORTION)	0.11
2	E 6S T3 BOTTOM	0.18

REMARKS: Tested for information. Corrosion threshold for uncoated reinforcement is 1.2 lb/yd^3.
Tested in accordance with ASTM C1213.

cc: S. Kahl

Signed _____
Supervising Engineer, Experimental Studies