2005 NS Admixture to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete (ASTM C 1582)

Prepared for:

Cortec Corporation
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Attn: Jesse Jackson-Meyer

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TOURNEY CONSULTING GROUP, LLC

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1. Introduction

TCG has conducted ASTM C1582 compliance testing on the following product supplied by Cortec:

- MCI 2005-NS

The scope of the project was to perform laboratory testing of concrete batched with and without chemical admixtures in accordance with the requirements of ASTM C1582 "Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete." There are two unique aspects of ASTM C1582; one relates to corrosion inhibiting performance (ASTM G109) and the other relates to the physical properties of concrete containing additives (similar to ASTM C494). This report will present both the physical properties of the concrete along with the corrosion related properties.

All sample preparation and testing was performed in accordance with the applicable sections of ASTM C1582.

2. Testing

2.1. Sample Preparation

All samples were prepared using concrete fabricated by TCG personnel at our facility in Kalamazoo, Michigan. Sample preparation began with the first day of batching on January 13, 2010 and continued on subsequent days until batching was completed on February 8, 2010. Below is a table representing the average mixture properties of all concrete batched.

	Control	2005 NS
Water, lb/yd^3	300	300
Lafarge Type II Cement, lb/yd^3	600	600
Consumer Sprinkle Rd Pit Sand, lb/yd^3	1122	1122
Port Inland Pit 25A, lb/yd^3	1780	1780
Master Builder AE 90 (air), oz/yd^3	4.1	3.0
Admixture (Test), gal/yd^3	-	0.188
w/cm	0.50	0.50
Slump, inches	6.79	7.42
Air Content, %	6.6	6.4

*lb/yd^3

2.2. Physical Properties

Compressive strength, flexural strength, set time, shrinkage, and freeze/thaw were tested according to the requirements of ASTM C1582, which follows the same testing procedures found in ASTM C494. Below are tables showing the physical properties.

Table 1 – MCI 2005NS Physical Properties

MCI 2005NS					
	Control	MCI 2005NS	Relative to Control	ASTM C1582 Requirements	Results
Initial Set (Minutes)	308	318	+ 10	+/- 210 Min of Control	Meets Requirement
Final Set (Minutes)	406	419	+ 13	+/- 210 Min of Control	Meets Requirement
Compressive Strength					
3-Day (psi)	3297	3137	95%	Min 80% of Control	Meets Requirement
7-Day (psi)	4080	4087	100%	Min 80% of Control	Meets Requirement
28-Day (psi)	5167	5340	103%	Min 80% of Control	Meets Requirement
6-Month (psi)	6207	6517	105%	Min 80% of Control	Meets Requirement
1-Year (psi)	6463	6773	105%	Min 80% of Control	Meets Requirement
Flexural Strength					
3-Day (psi)	575	591	103%	Min 80% of Control	Meets Requirement
7-Day (psi)	645	654	101%	Min 80% of Control	Meets Requirement
28-Day (psi)	747	767	103%	Min 80% of Control	Meets Requirement
Length Change (%)	-0.0245	-0.021	0.003%	Max 0.010 over Control	Meets Requirement
Freeze/Thaw Durability	98.5	97.1	98.6%	RDF 80%	Meets Requirement

2.3. Corrosion Properties

Corrosion properties were tested according the ASTM C1582 which references ASTM G109 "Test Method for Determining Effects of Chemical Admixtures on Corrosion of Embedded Steel Reinforcement in Concrete Exposed to Chloride Environments".

The control beams reached 50 Coulombs at an age of 249 weeks at which point a chloride analysis was completed and ponding was continued until they reached 150 Coulombs at an age of 301 weeks at which point the routine ponding was complete. Below is a chart summarizing the corrosion properties at the completion of testing.

Table 2 – MCI 2005NS Corrosion Properties

MCI 2005NS						
	Control	**MCI 2005NS**	**Relative to Control**		**ASTM C1582 Requirements**	**Results**
Average Integrated Current, C	**155**	**29**	**n/a**		**≤50 C when Control is 150 C**	**Meets Requirement**
Average Area Corroded, in²	**8.93**	**2.36**	**29%**		**≤ 1/3 of Control**	**Meets Requirement**
Critical Chloride Content*, ppm	**2861**	**2898**	**101%**		**≥ Critical Control**	**Meets Requirement**

*critical chloride content (based on control average at 50 Coulombs plus one standard deviation)

3. Summary of Findings

Upon completion of testing TCG was able to conclude that the MCI 2005 NS admixture can be classified as corrosion inhibiting admixtures according to ASTM C1582.

Sincerely,
Tourney Consulting Group, LLC

Neal S. Berke, PhD	Kristin Ade, P.E.	Larry Wachowski
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APPENDIX

1. Integrated Macrocell Current

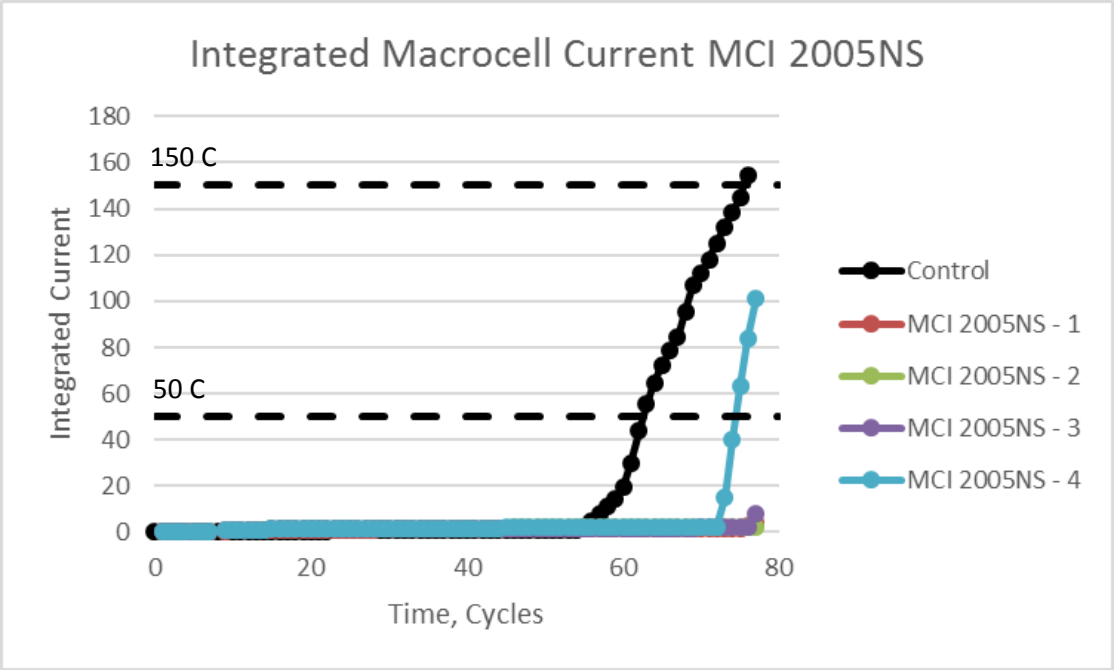

Figure 1 – MCI 2005NS Integrated Macrocell Current

Table 3 – Total Integrated Macrocell Current as Testing Completion

Integrated Macrocell Current			
Control-1	141	2005NS-1	4
Control-2	160	2005NS-2	2
Control-3	115	2005NS-3	8
Control-4	202	2005NS-4	101
Average	155	Average	29

2. Corrosion Area

Table 4 – Corrosion Found on Top Reinforcing Bar

Corrosion Area			
Control-1	9.42	2005NS-1	0
Control-2	10.99	2005NS-2	0
Control-3	3.53	2005NS-3	1.57
Control-4	11.78	2005NS-4	7.87
Average	8.93	Average	2.36

3. Chloride Content

Table 5 – Chloride Content

Chloride Content, ppm			
Control-1	2241	2005NS-1	2899
Control-2	2468	2005NS-2	2420
Control-3	2063	2005NS-3	2429
Control-4	2948	2005NS-4	3314
Control-5	2591	2005NS-5	3790
Control-6	2865	2005NS-6	2630
Control-7	2307	2005NS-7	2577
Control-8	2812	2005NS-8	3123
Control-9	2700		
Average	2555	Average	2898
St. Dev.	306	St. Dev.	1006

4. Corrosion Photos

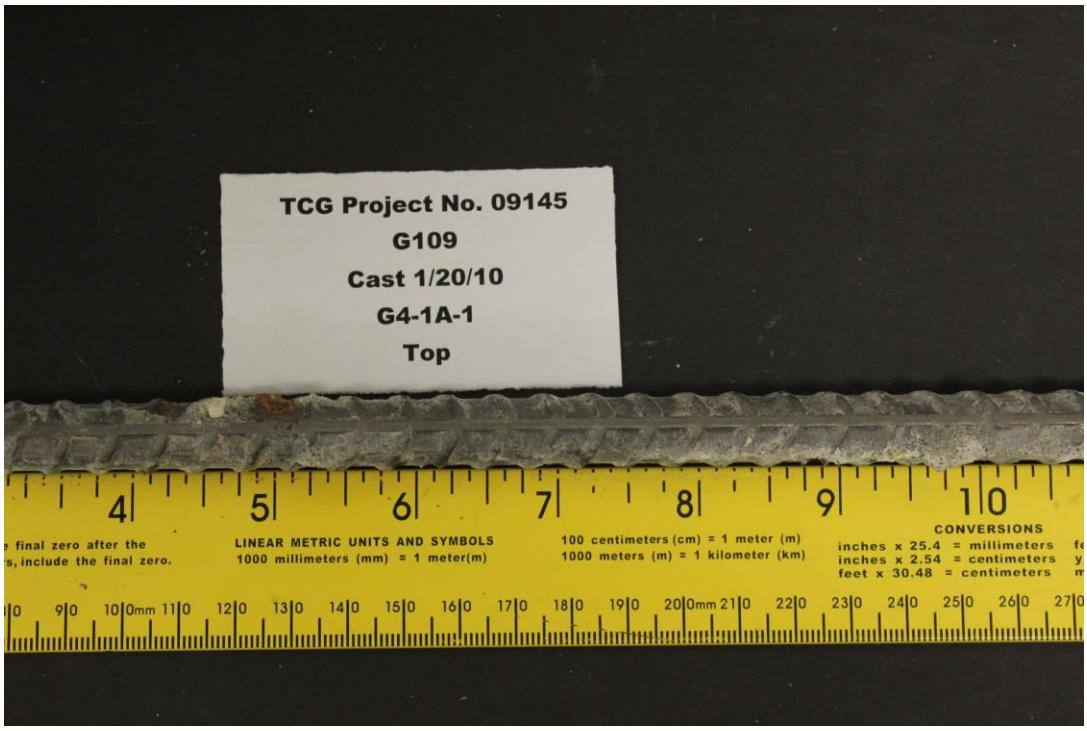

Figure 2 - Top Bar from Control Beam, showing the top surface

Figure 3 – Top Bar from Control Beam, showing the bottom surface

Figure 4 - Top Bar from Control Beam, showing the top surface

Figure 5 – Top Bar from Control Beam, showing the bottom surface

Figure 6 - Top Bar from Control Beam, showing the top surface

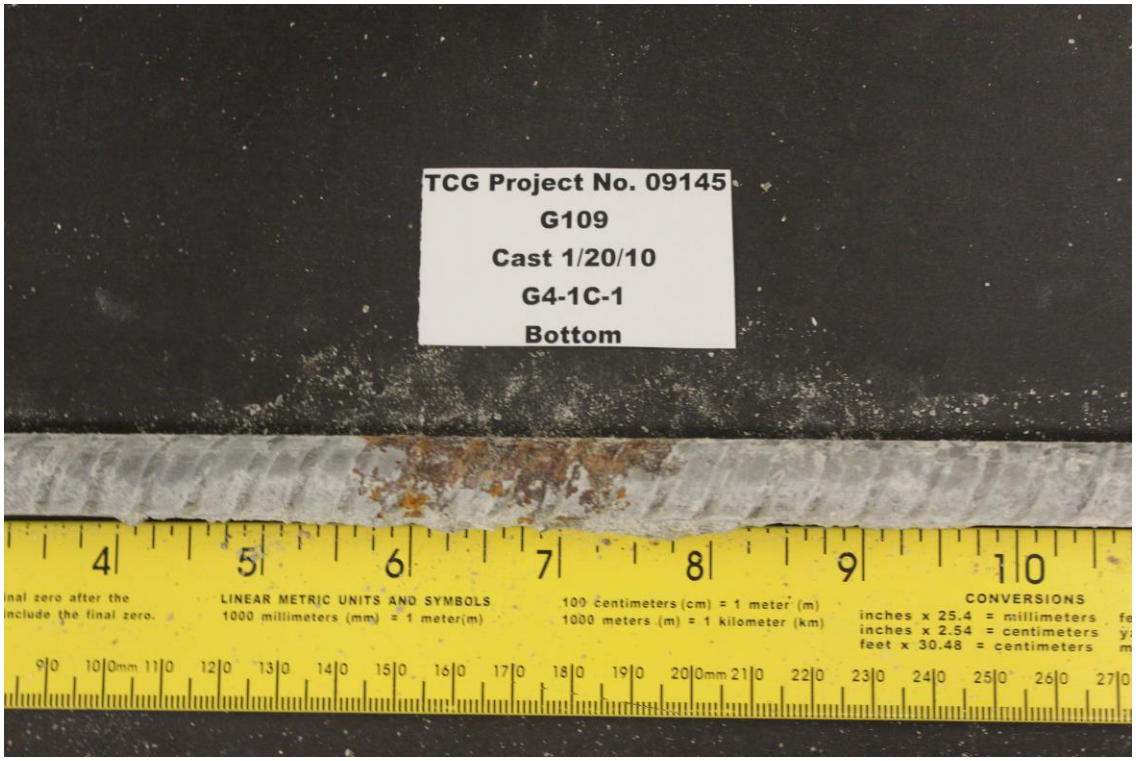

Figure 7 – Top Bar from Control Beam, showing the bottom surface

Figure 8 - Top Bar from Control Beam, showing the top surface

Figure 9 – Top Bar from Control Beam, showing the bottom surface

Figure 10 - Top Bar from 2005NS Beam, showing the top surface

Figure 11 – Top Bar from 2005NS Beam, showing the bottom surface

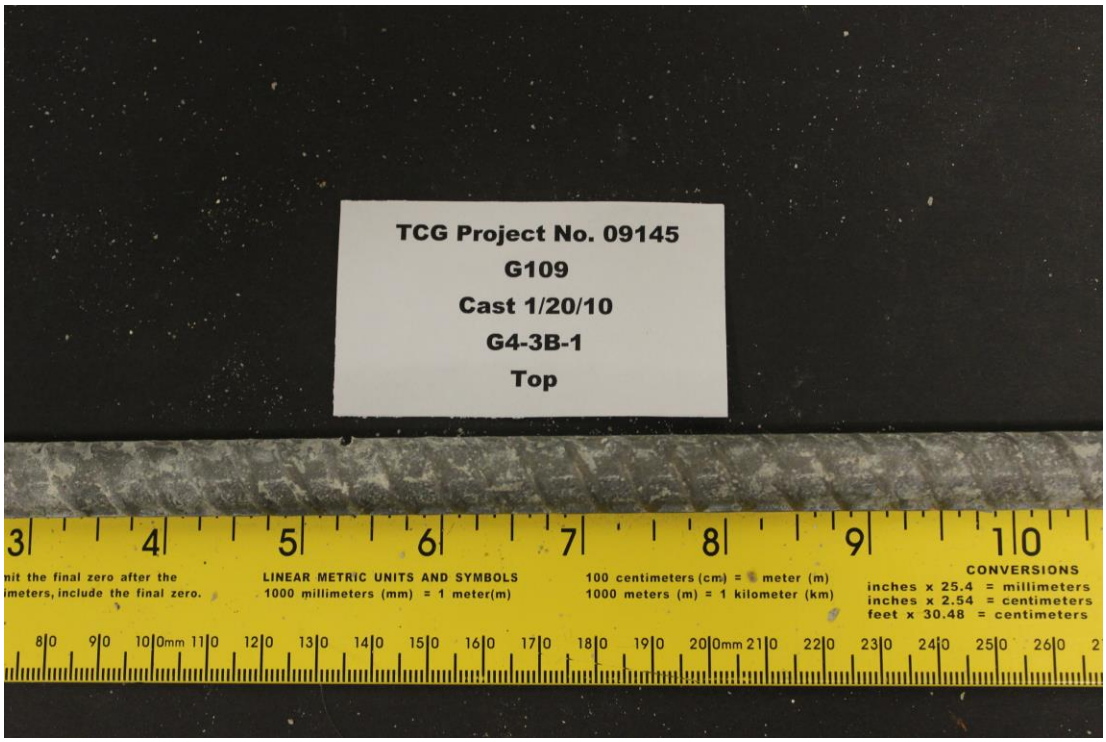

Figure 12 - Top Bar from 2005NS Beam, showing the top surface

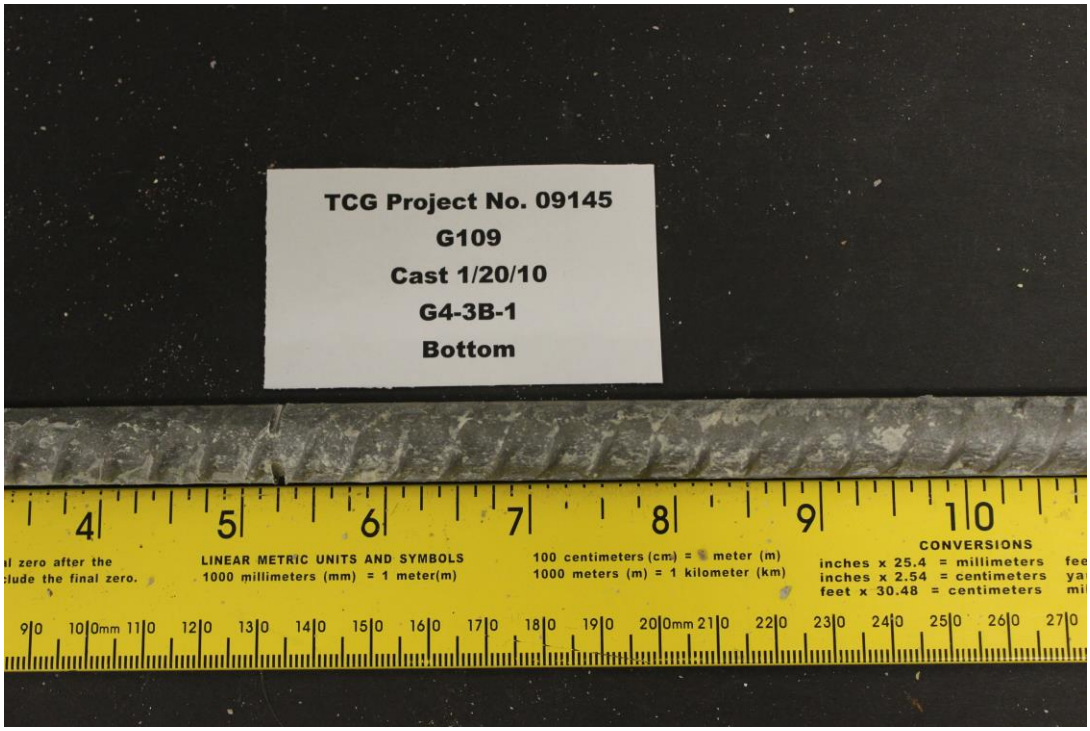

Figure 13 – Top Bar from 2005NS Beam, showing the bottom surface

Figure 14 - Top Bar from 2005NS Beam, showing the top surface

Figure 15 – Top Bar from 2005NS Beam, showing the bottom surface

Figure 16 - Top Bar from 2005NS Beam, showing the top surface

Figure 17 – Top Bar from 2005NS Beam, showing the bottom surface