

## Carbocolor in Concrete – ASTM C979

Concrete can be pigmented to a dark grey color using carbon black or iron oxide. Carbocolor is a carbon black which imparts a dark grey color with a blue-green undertone as opposed to the yellow-red undertone seen with iron oxide. The large particle size of Carbocolor provides advantages over other carbon blacks in mixing and weathering. In this study, Carbocolor was tested to the requirements of ASTM C979 *Standard Specification for Pigments for Integrally Colored Concrete*. Carbocolor was tested for water wettability, alkali resistance, SO<sub>3</sub> percentage, water solubility, atmospheric curing stability, light resistance, and effects on concrete properties as per the standard. The mixing and testing were completed at American Engineering Testing (AET) in Saint Paul, MN. Light resistance testing was completed at Nike-Tech in Alvarado, TX.

**Carbocolor met the requirements of ASTM C979 Sections 8.1, 8.2, 8.4, 8.6, and 8.7. For Section 8.3, the test method specified in the standard is not applicable to carbon black. For Section 8.5, there was a noticeably darker color for the pigmented specimens cured in a high humidity environment.**

A summary of the test results for Sections 8.1, 8.2, 8.3, and 8.4 of ASTM C979 can be found in Table 1. The Carbocolor sample met the requirements of Sections 8.1, 8.2, and 8.4. The sample could not be tested to the method laid out in Section 8.3 as it is not soluble in hydrochloric acid. That being said, the percentage of total sulfates in the material, determined by other methods, is well below 0.1% which easily meets the ASTM C979 requirement.

**Table 1.** Summary of test results for Sections 8.1, 8.2, 8.3, and 8.4 of ASTM C979

	Result	ASTM C979 Requirements
<b>Section 8.1 Water Wettability</b>	Wettable, Slight Water Repellency	Water Wettable
<b>Section 8.2 Alkali Resistance</b>	Resistant, No Significant Change	No Visual Color Change
<b>Section 8.3 Percentage of SO<sub>3</sub></b>	N/A <sup>1</sup>	<5.0% mass of original sample
<b>Section 8.4 Water Solubility</b>	0.20%	<2.0% mass of original sample

<sup>1</sup> The tested sample was not soluble in hydrochloric acid and therefore testing was terminated. Based on the chemical composition of the sample, it does not fall within the scope of the test method which states "The test methods apply specifically to the following pigments: synthetic hydrated yellow iron oxide, yellow ochre, red and brown iron oxides, raw and burnt umber, raw and burnt sienna and venetian red."

A summary of the test results for Section 8.5 of ASTM C979 can be found in Table 2. For the concrete loaded with 6% Carbocolor by weight of cement mass, a significantly darker color was observed for the samples cured under high humidity conditions. It is well known that curing concrete under high humidity conditions can cause concrete to appear darker due to the slower rate of water evaporation from the concrete surface.

A summary of the test results for Section 8.6 of ASTM C979 can be found in Table 3. With a loading of only 0.5% Carbocolor, there was a significant change in color after light exposure. However, at the 6% loading, the color change was minimal. Generally, we recommend loadings between 4% and 10% to obtain the best performance.

A summary of the test results for Section 8.7 of ASTM C979 can be found in Tables 4 and 5. All requirements of ASTM C979 were met. The average compressive strength of the specimens with 10% Carbocolor were higher than the control specimens.

**Table 2.** Summary of test results for Section 8.5 of ASTM C979

<b>Low Humidity (At Least 50%)</b>	<b>Average</b>		
<b>Test Specimen</b>	<b>L*</b>	<b>a*</b>	<b>b*</b>
Control A (No Pigment)	83.4	0.11	4.35
Control B (No Pigment)	85.1	-0.06	4.01
1/2% - A	60.5	-1.05	-4.00
1/2% - B	59.9	-1.12	-4.19
6% - A	46.2	-0.96	-4.15
6% - B	46.7	-0.96	-4.14
<b>High Humidity (100%)</b>	<b>Average</b>		
<b>Test Specimen</b>	<b>L*</b>	<b>a*</b>	<b>b*</b>
Control A (No Pigment)	85.8	-0.04	3.20
Control B (No Pigment)	85.6	0.03	3.53
1/2% - A	56.5	-0.91	-3.15
1/2% - B	57.0	-0.89	-2.85
6% - A	33.6	-0.58	-2.83
6% - B	33.6	-0.56	-2.79

**Table 3.** Summary of test results for Section 8.6 of ASTM C979

Test Specimen	Light Exposure	Average			$\Delta E$
		L*	a*	b*	
Control (No Pigment)	Before	87.6	-0.39	3.47	0.67
	After	88.3	-0.44	3.37	
1/2% - A	Before	59.1	-1.07	-3.47	2.54
	After	57.0	-0.78	-2.20	
6% - A	Before	34.3	-0.51	-2.6	0.11
	After	34.4	-0.48	-2.51	

**Table 4.** Summary of test results for Section 8.7 of ASTM C979

	Concrete Mixture Proportions, per yd <sup>3</sup> , SSD		
Materials	Control	10% Pigment	ASTM C979 Requirements
Royal White Type 1 White Portland Cement, lb	517	517	517±5
Carbocolor Black Pigment, lb	--	51	≤10% by mass of cement
Martin Marietta Sand, Elk River, WI, lb	1271	1270	
Martin Marietta #57 Granite, St. Cloud, MN, lb	1765	1756	
Potable Water, City of St. Paul, MN, lb	286	290	
Mapei Polychem Vinsol Resin Air-Entraining Admixture, fl.oz./cwt	1	1.8	
Air Content, % (assumed)	6	6	
Water-to-Cement Ratio	0.55	0.56	
Water-to-Cement Ratio, relative to control	--	101%	≤110%
<b>Concrete Plastic Properties</b>			
ASTM C231, Air Content, %	7	6.1	±1.0% of control
ASTM C143, Slump, inches	3.5	3.75	4.00±0.50
ASTM C138, Unit Weight, lb/ft <sup>3</sup>	144	144.8	
ASTM C1064, Temperature, °F	68	68	
<b>Time of Setting – ASTM C403</b>			
Initial Set, minutes	387	391	Acceleration ≤ 1.0 hr Retardation ≤ 1.5 hr
Final Set, minutes	481	474	

**Table 5.** Summary of test results for Section 8.7.5 of ASTM C979 - Compressive Strength

<b>Concrete Mix I.D.</b>	<b>Control (No Pigment)</b>			<b>10% Pigment</b>		
Age at Test, days	7 days			7 days		
Cylinder No.	1	2	3	1	2	3
Average Diameter, in.	4.00	4.00	4.00	3.99	4.00	4.00
Cross-Sectional Area, in <sup>2</sup>	12.59	12.54	12.57	12.53	12.58	12.57
Length Before Capping, in	8.00	8.02	8.00	8.02	8.03	8.04
Mass, lbm	8.5	8.6	8.6	8.6	8.6	8.6
Density, lb/ft <sup>3</sup>	145.8	147.7	147.8	147.8	147.0	146.9
Maximum Load, lbf	51961	54578	55300	54670	55748	58709
Fracture Pattern	3	2	5	6	2	5
Compressive Strength, psi	4126	4351	4398	4362	4431	4670
<b>Average Compressive Strength, psi</b>	<b>4290</b>			<b>4490</b>		
<b>Concrete Mix I.D.</b>	<b>Control (No Pigment)</b>			<b>10% Pigment</b>		
Age at Test, days	28 days			28 days		
Cylinder No.	1	2	3	1	2	3
Average Diameter, in.	4.00	4.00	4.00	4.01	4.00	4.00
Cross-Sectional Area, in <sup>2</sup>	12.57	12.54	12.57	12.62	12.59	12.57
Length Before Capping, in	8.02	8.06	8.01	8.00	8.05	8.05
Mass, lbm	8.54	8.60	8.53	8.59	8.61	8.61
Density, lb/ft <sup>3</sup>	146.5	147.1	146.3	147.0	146.9	147.2
Maximum Load, lbf	68747	65068	63726	67591	65225	69375
Fracture Pattern	3	5	2	2	5	3
Compressive Strength, psi	5469	5190	5070	5357	5181	5521
<b>Average Compressive Strength, psi</b>	<b>5240</b>			<b>5350</b>		